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Nakajima et al.

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(54) **ELECTRONIC EQUIPMENT, CONTROL INFORMATION TRANSMISSION AND RECEPTION METHODS HAVING BIDIRECTIONAL COMMUNICATION USING PREDETERMINED LINES**

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H04N 5/44 (2011.01)
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See application file for complete search history.

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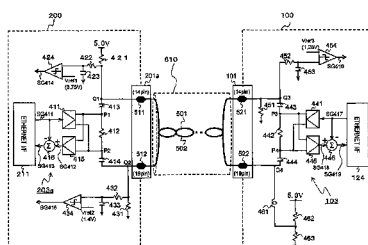
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(57) **ABSTRACT**

Electronic equipment and methods for permitting quick control of the operating state of a source equipment side from sink equipment. A television receiver (sink equipment) **100** and an amplifier (repeater equipment) **200** are interconnected over an HDMI cable **610**, and the amplifier **200** and a DVD recorder (source equipment) **300** are interconnected over an HDMI cable **620**. Each of the pieces of equipment includes, in addition to an HDMI receiving unit and an HDMI transmitting unit, a high-speed data line I/F included in a bidirectional communication unit that uses predetermined lines of the HDMI cable. The bidirectional communication unit is used to transmit channel selection information, a remote control code instructing recording, "theater mode" designating information, a remote control code, or the like from the television receiver **100** to the audio amplifier **200** or DVD recorder **300**.

1 Claim, 15 Drawing Sheets



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FIG. 1

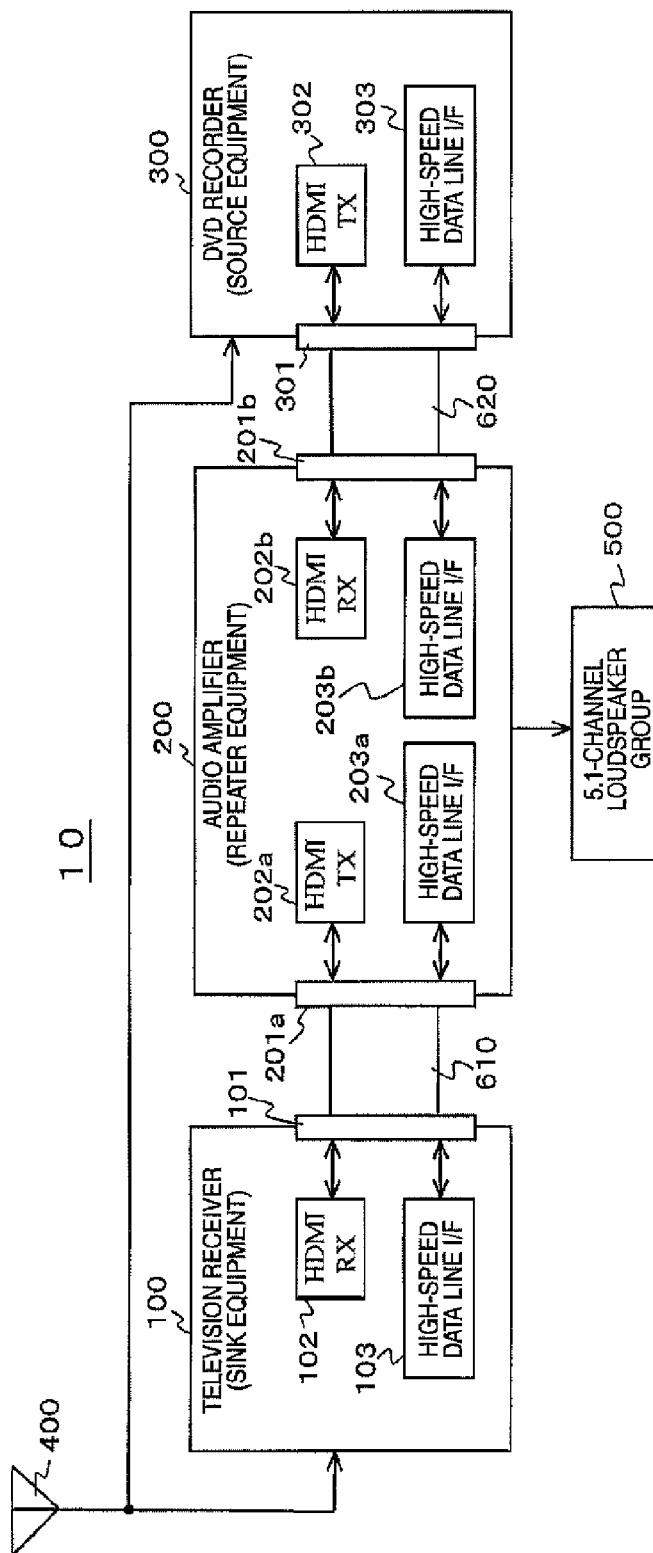


FIG. 2

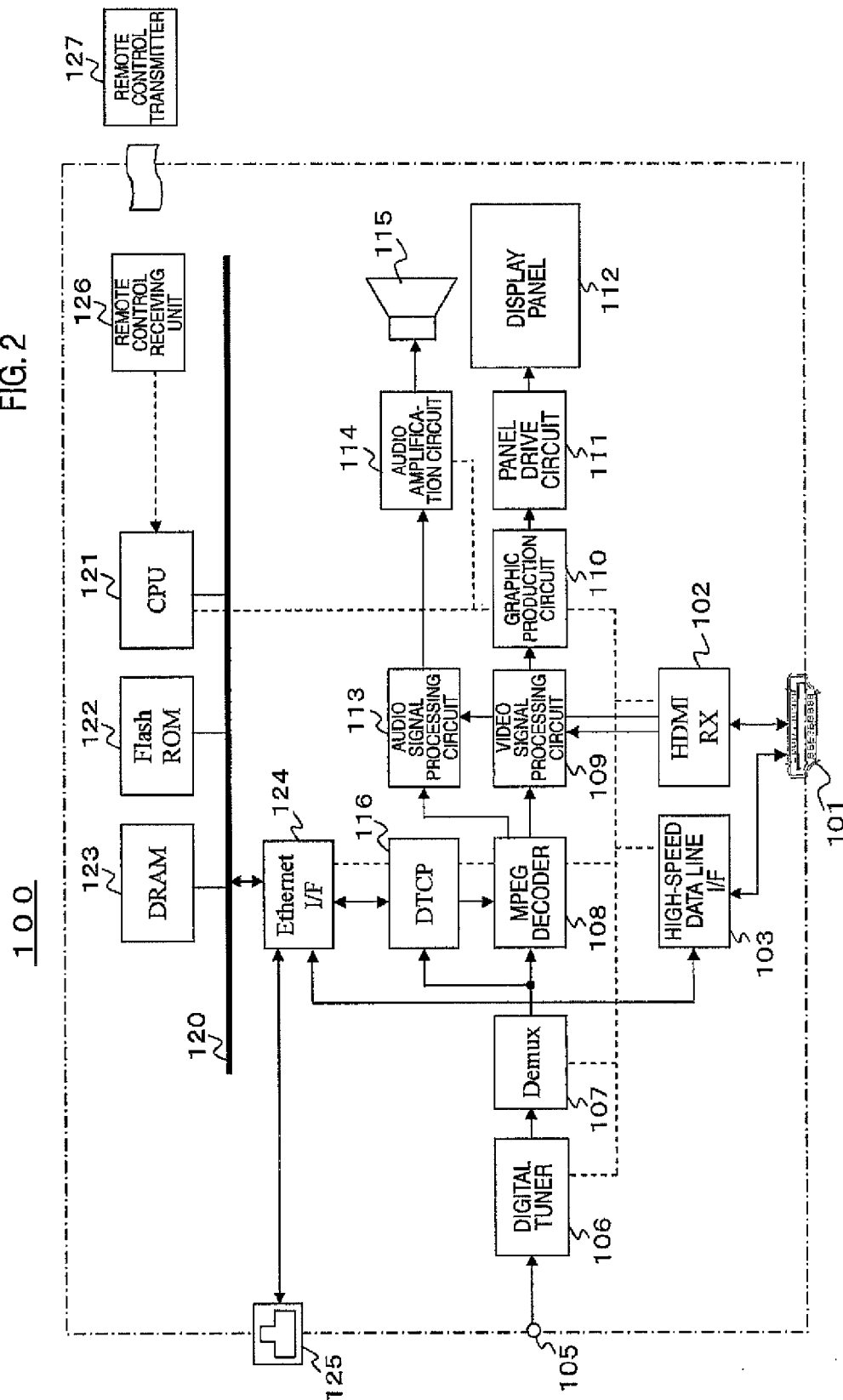


FIG. 3

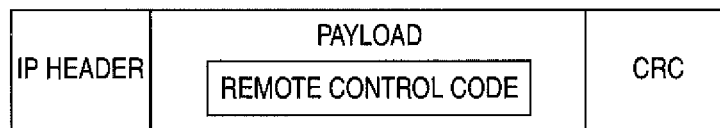
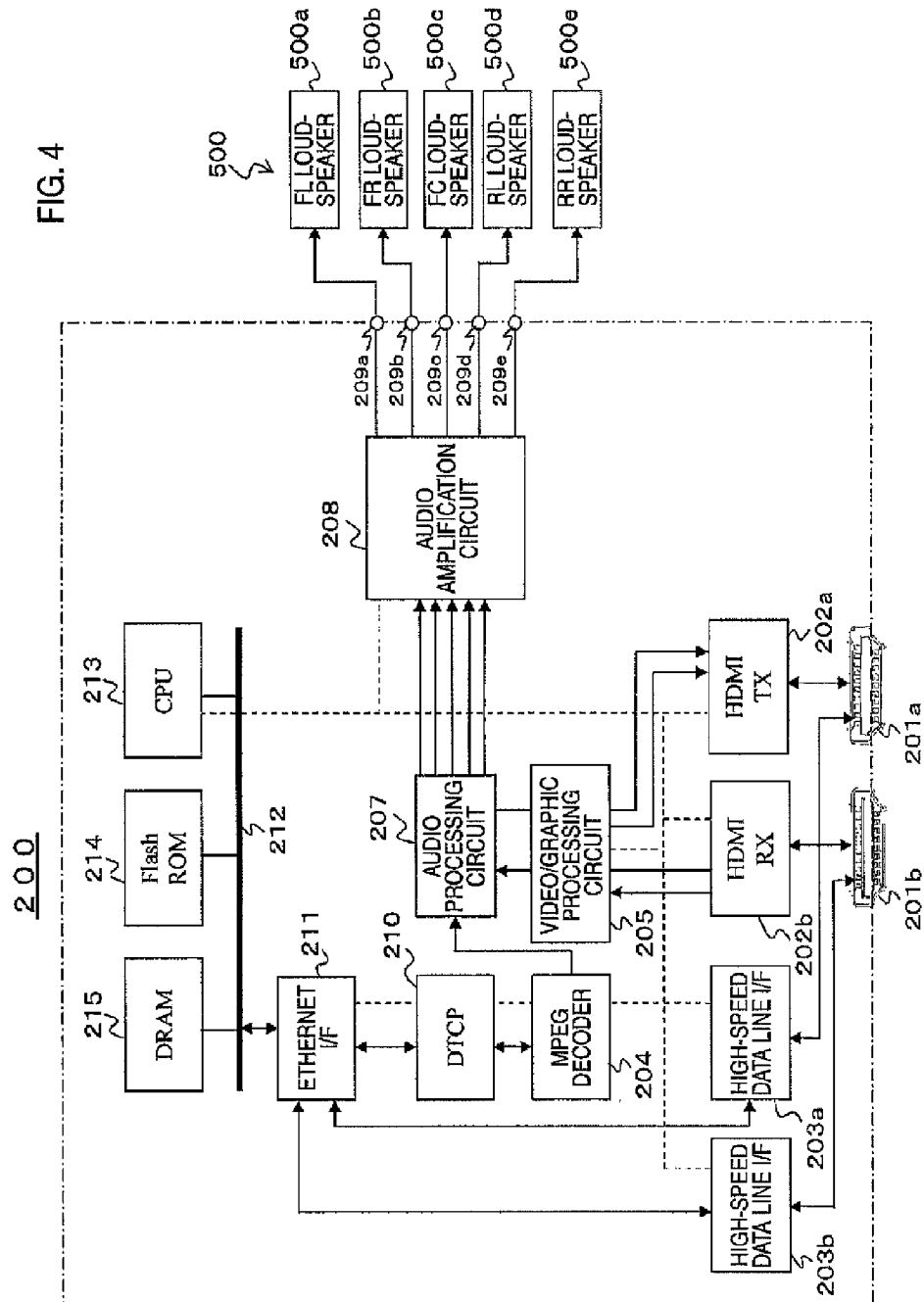
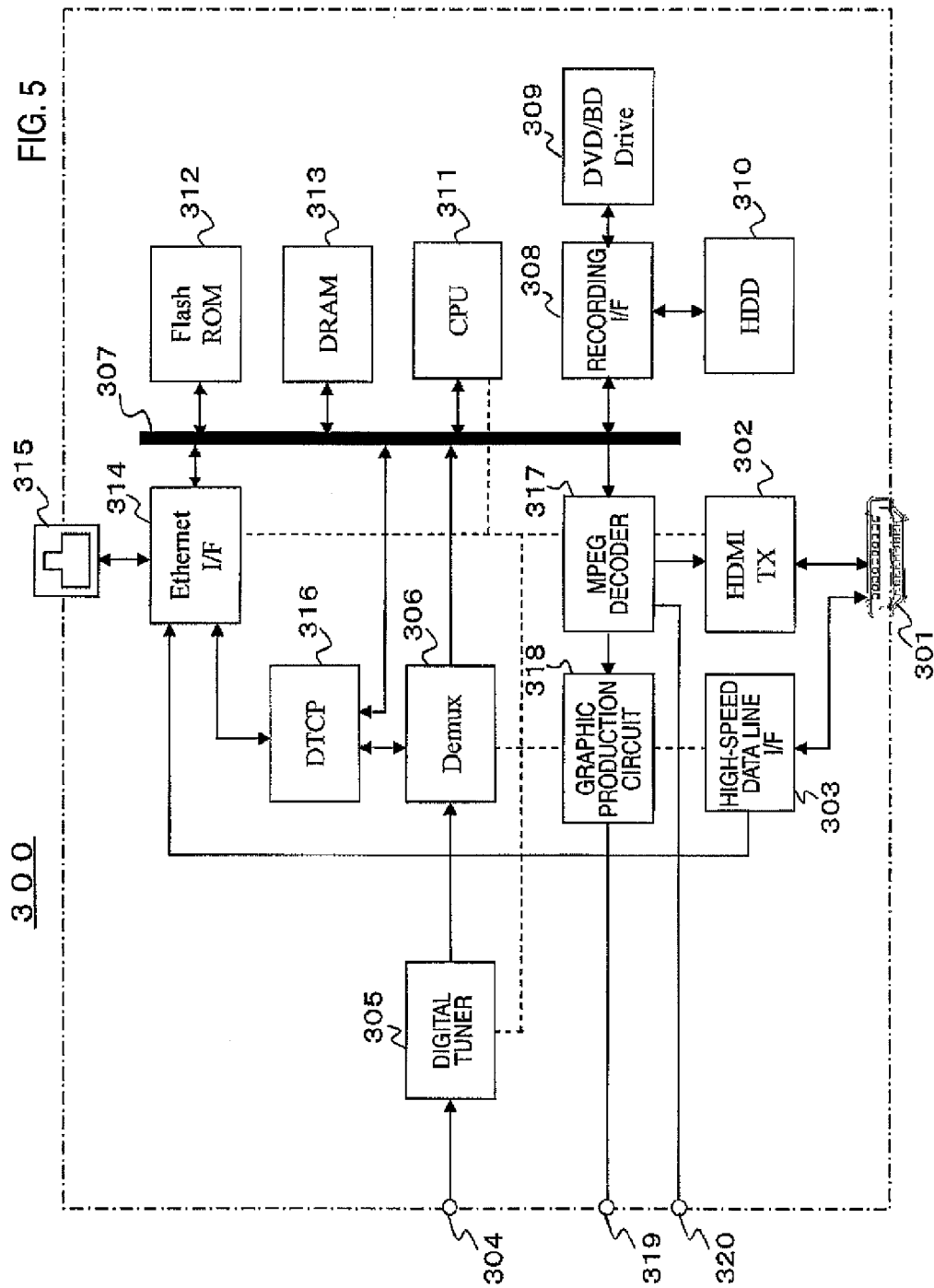


FIG. 4





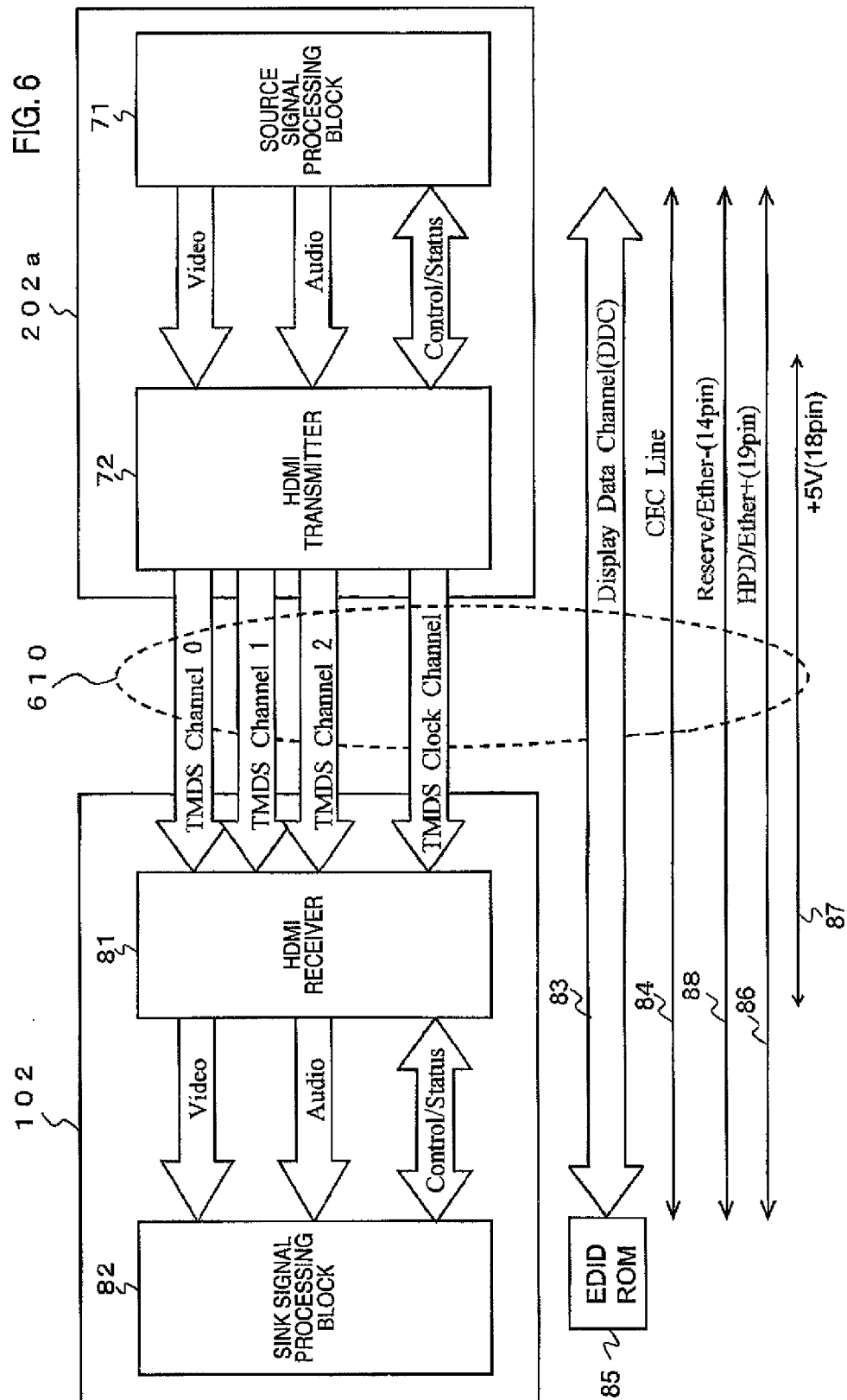


FIG. 7

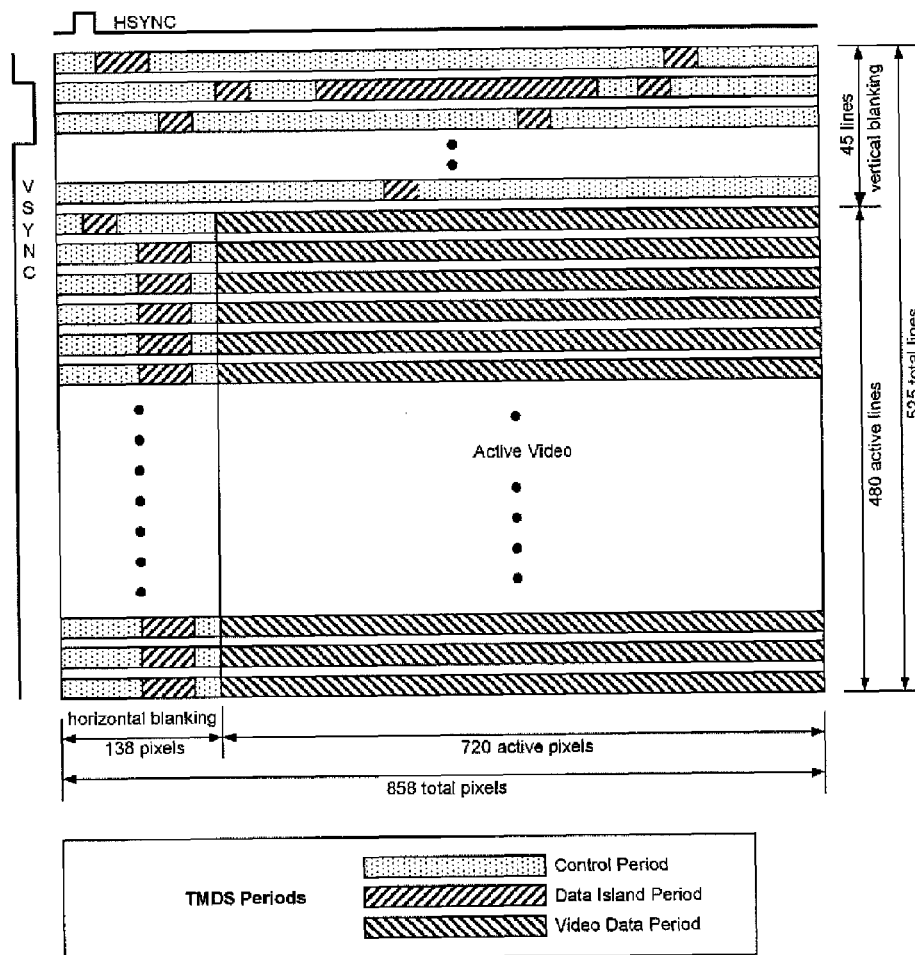


FIG. 8

PIN	Signal Assignment	PIN	Signal Assignment
1	TMDS Data2+	2	TMDS Data2 Shield
3	TMDS Data2−	4	TMDS Data1+
5	TMDS Data1 Shield	6	TMDS Data1−
7	TMDS Data0+	8	TMDS Data0 Shield
9	TMDS Data0−	10	TMDS Clock+
11	TMDS Clock Shield	12	TMDS Clock−
13	CEC	14	Reserved (N.C. on device)
15	SCL	16	SDA
17	DDC/CEC Ground	18	+5V Power
19	Hot Plug Detect		

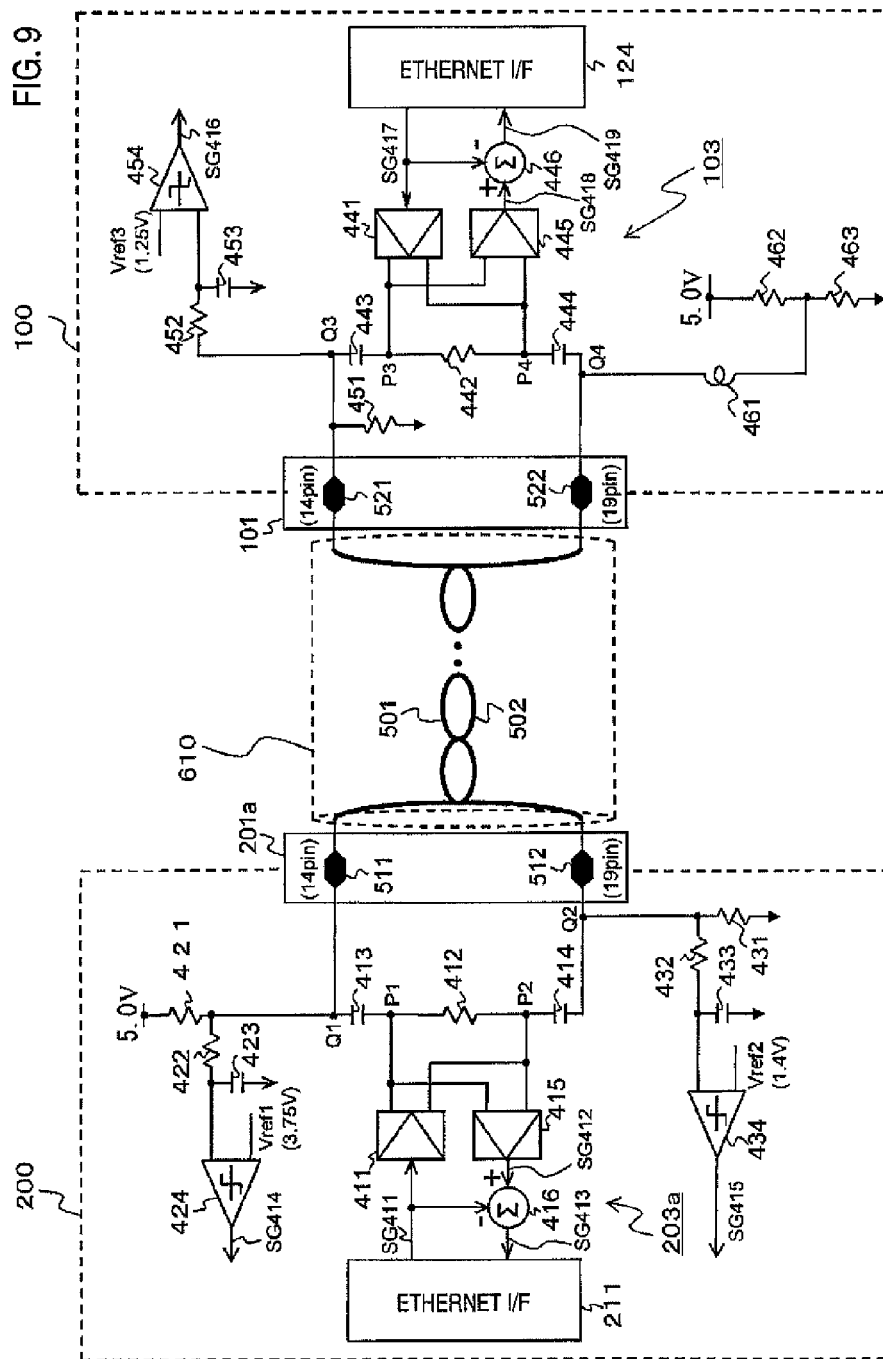


FIG. 10

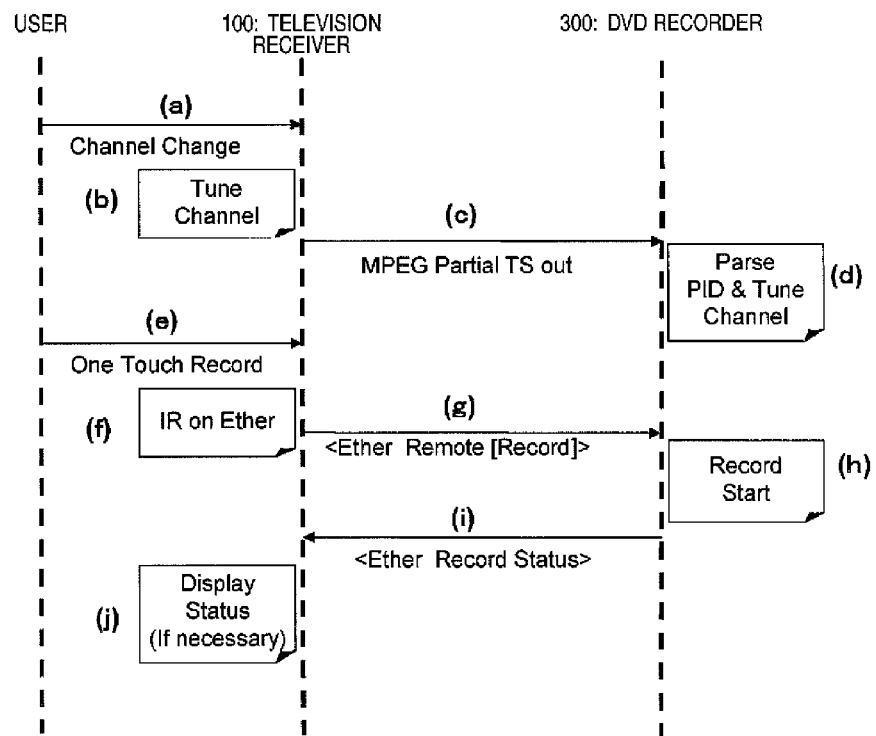


FIG. 11

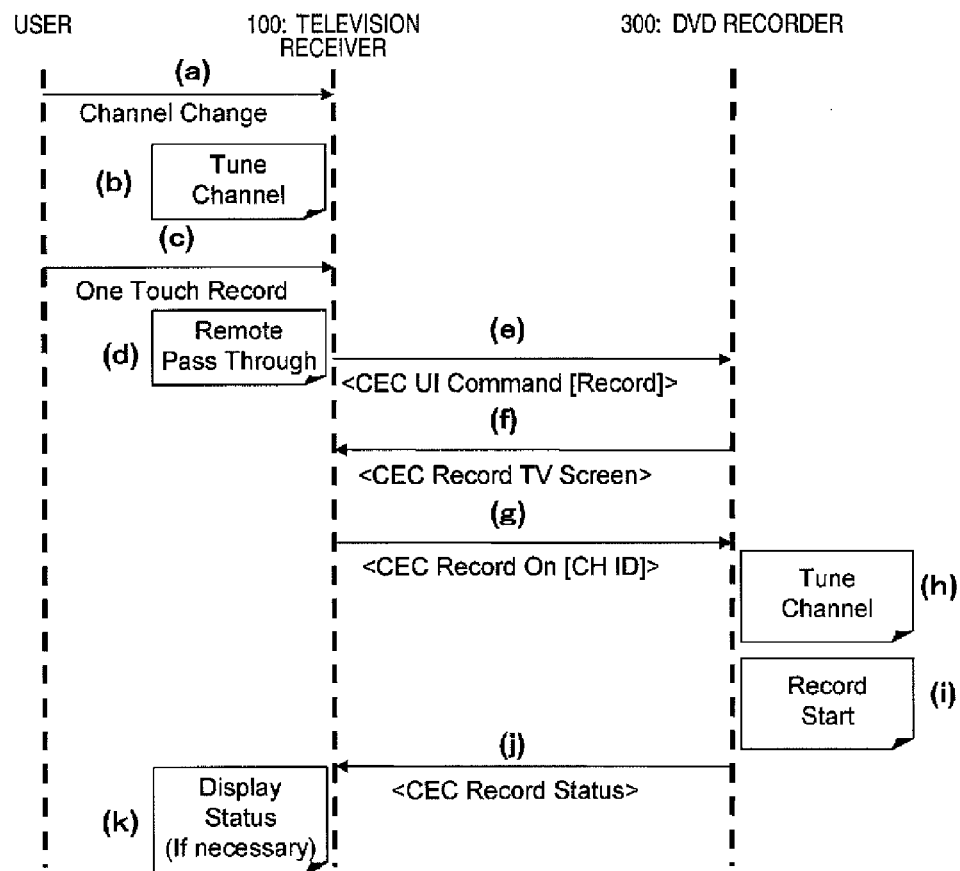


FIG. 12

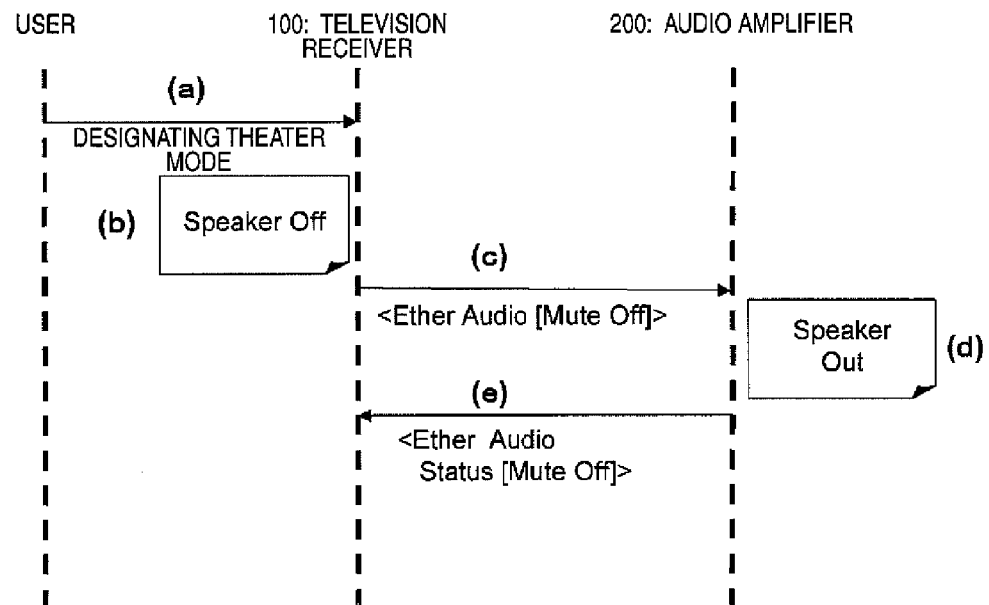


FIG. 13

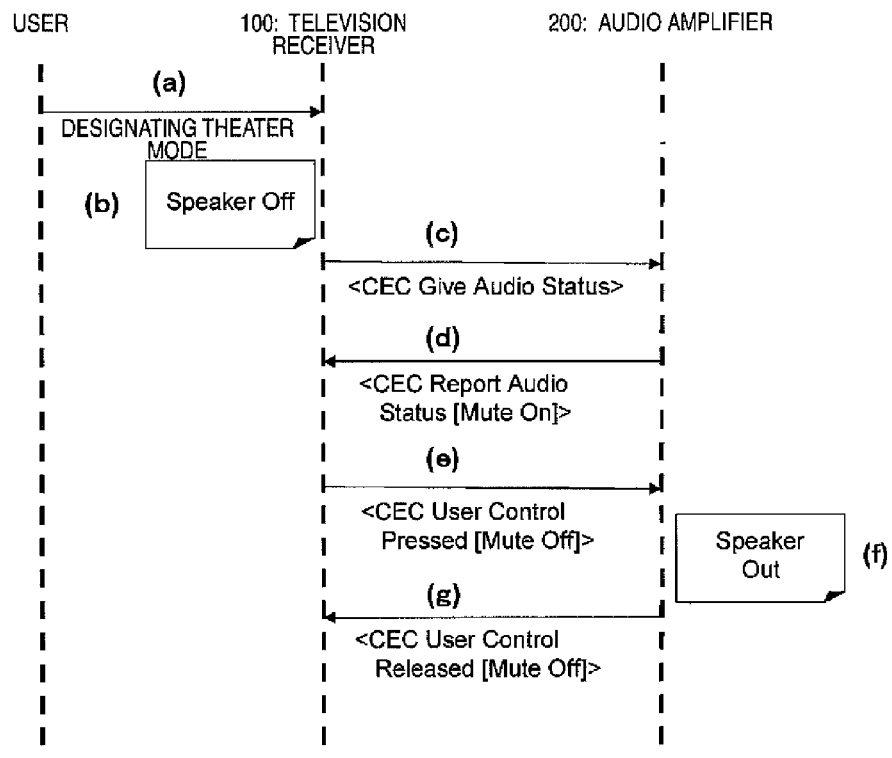


FIG. 14

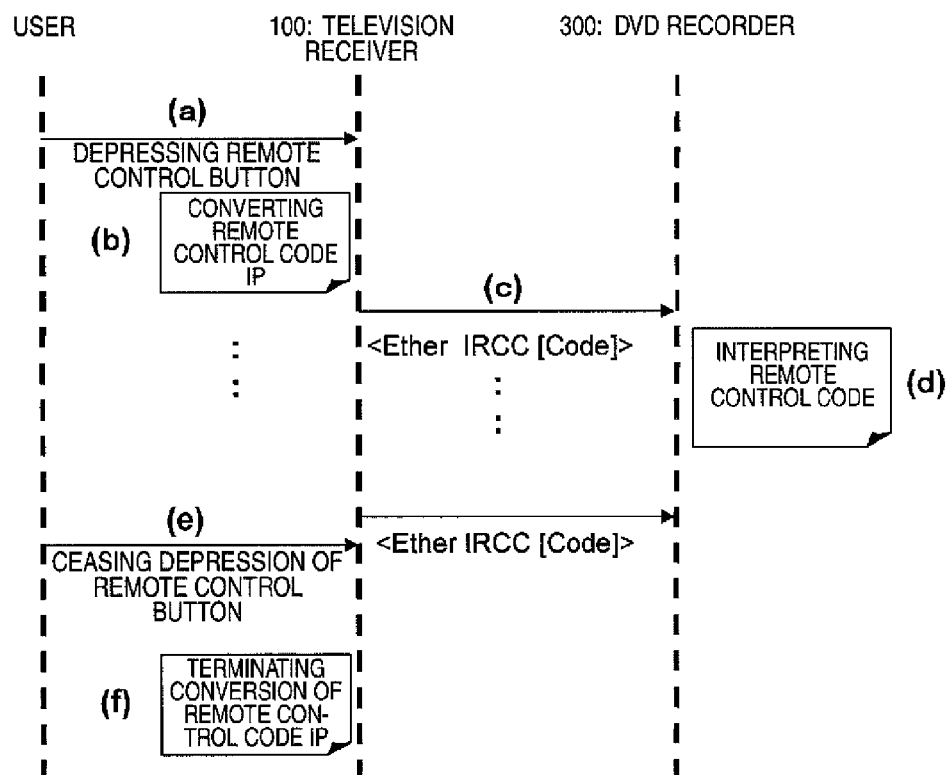
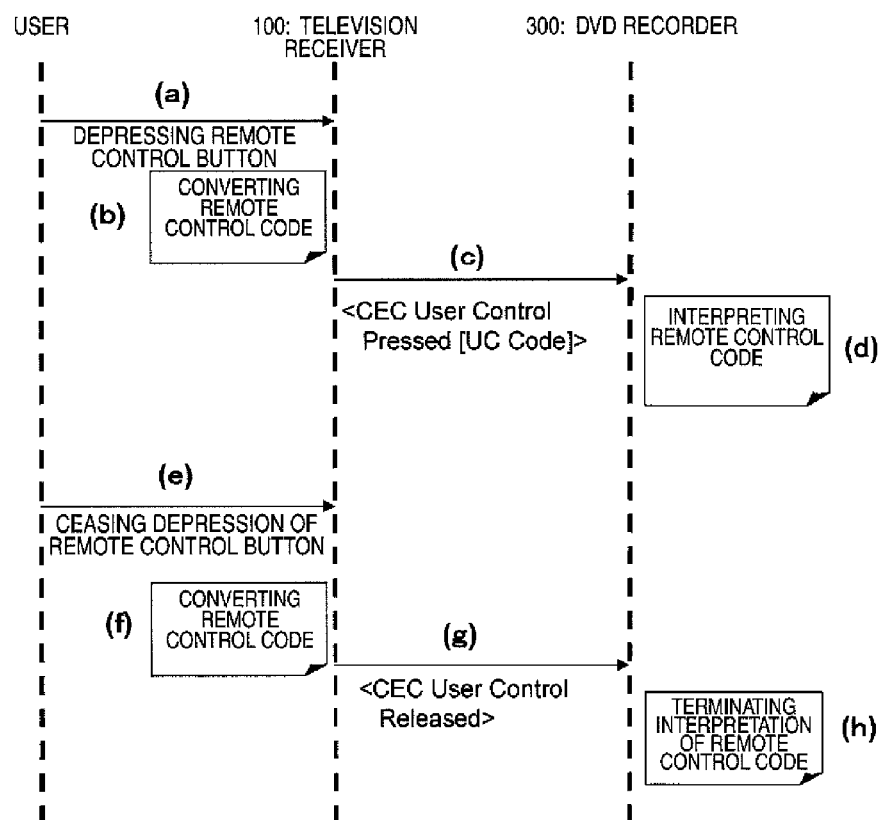


FIG. 15



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**ELECTRONIC EQUIPMENT, CONTROL
INFORMATION TRANSMISSION AND
RECEPTION METHODS HAVING
BIDIRECTIONAL COMMUNICATION USING
PREDETERMINED LINES**

**CROSS-REFERENCES TO RELATED
APPLICATIONS**

The present application is a continuation of U.S. application Ser. No. 14/295,887, filed on Jun. 4, 2014, which is a continuation of U.S. application Ser. No. 14/021,292, filed on Sep. 9, 2013, now U.S. Pat. No. 8,848,111, which is a continuation of U.S. application Ser. No. 12/312,353, filed on Nov. 24, 2009, now U.S. Pat. No. 8,587,723, which is a national phase entry under 35 U.S.C. §371 of International Application No. PCT/JP2007/071649 filed Nov. 7, 2007, published on May 15, 2008 as WO 2008/056707 A1, which claims priority from Japanese Patent Application No. JP 2006-301486 filed in the Japanese Patent Office on Nov. 7, 2006, Japanese Patent Application No. JP 2007-050426 filed in the Japanese Patent Office on Feb. 28, 2007, and Japanese Patent Application No. JP 2007-201517 filed in the Japanese Patent Office on Aug. 2, 2007, all of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to electronic equipment, a control information transmission method, and a control information reception method that employ a communication interface, for example, the high definition multimedia interface (HDMI). More particularly, the invention is concerned with electronic equipment that includes a communication unit which performs bidirectional communication using predetermined lines included in a transmission line, that uses the communication unit to transmit control information to another electronic equipment, and that thus can quickly control the operating state of the another electronic equipment. The invention is concerned with electronic equipment that includes a communication unit which performs bidirectional communication using predetermined lines included in a transmission line, that uses the communication unit to receive control information from another electronic equipment, that controls the operating state on the basis of the control information, and that thus permits quickly control of the operating state from the another electronic equipment side.

BACKGROUND ART

In recent years, the HDMI has prevailed as a communication interface under which a digital video signal, that is, a non-compressed (baseband) video signal (hereinafter, referred to as image data), and a digital audio signal accompanying the video signal (hereinafter, referred to as audio data) are transmitted from, for example, a digital versatile disc (DVD) recorder, a set-top box, or any another audiovisual (AV) source to a television receiver, a projector, or any another display (refer to, for example, a patent document 1).

Between pieces of equipment interconnected under the HDMI, control is implemented under the consumer electronics control (CEC) standard stipulated in the HDMI. However, the CEC standard succeeds a data structure and a transmission speed defined for equipment control through a SCART (syndicat des constructeurs d'appareils radiorecepteurs et teleseurs) terminal in an analog mode. Therefore the transmission speed for control information is as low as approxi-

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mately 400 bps, and the data structure is defined to basically support transmission in units of 16 bytes. The transmission speed and data structure are therefore unsuitable for control that requires a high-speed response or transmission of control information whose length exceeds 16 bytes.

In a patent document 2, a proposal is made of a technology in which when a received partial transport stream (TS) is outputted from a transmission unit to another video equipment or device, message information alone is separated and extracted, converted into a universal plug and play (UPnP) representation, and then outputted from the transmission unit. In a patent document 3, a proposal is made of equipment in which: data and control information are transferred between a receiving device and a recording device; and the receiving device side includes a processing means which deals with recording control.

Patent document 1: JP-A-2006-319503

Patent document 2: JP-A-2006-319573

Patent document 3: JP-A-2003-209775

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

The technology described in the patent document 2 is not concerned with control between pieces of equipment. The technology described in the patent document 3 is concerned with control between pieces of equipment but is not concerned with control between pieces of equipment interconnected under the HDMI.

An object of the invention is to permit quick control of the operating state of a source equipment side from sink equipment.

Means for Solving the Problem

The concept of the invention lies in electronic equipment that includes a signal receiving unit which receives a video signal sent from another electronic equipment over a transmission line by means of differential signals on multiple channels.

The electronic equipment is characterized in that: the electronic equipment further includes a communication unit which performs bidirectional communication using predetermined lines included in the transmission line; and the communication unit transmits control information, which is used to control at least the operating state of the another electronic equipment side, to the another electronic equipment.

The electronic equipment of the invention includes the signal receiving unit that receives a video signal sent from another electronic equipment over a transmission line by means of differential signals on multiple channels, and is, for example, HDMI-conformable sink equipment or repeater equipment. In the invention, the communication unit that performs bidirectional communication using the predetermined lines included in the transmission line is further included. The communication unit is used to transmit control information to another electronic equipment. In this case, the control information can be quickly sent to another electronic equipment, and the operating state of the another electronic equipment side can be quickly controlled.

In the invention, for example, a broadcast receiving unit that acquires a video signal on a predetermined channel on the basis of a television broadcast signal, a display unit that displays a picture represented by the video signal acquired by the broadcast receiving unit, and a user operating unit which a user uses to instruct recording of the video signal relevant to

the picture displayed on the display unit may be further included. The communication unit may transmit not only information on channel selection in the broadcast receiving unit but also information on recording instruction made using the user operating unit. In this case, the channel selected in the broadcast receiving unit existing on the another electronic equipment side can be switched to a channel relevant to the picture displayed on the display unit. When user's recording instruction is made, a recording unit on the another electronic equipment side can immediately initiate recording of a video signal relevant to the picture displayed on the display unit.

In the invention, for example, a broadcast receiving unit that acquires a video signal and an audio signal on the basis of a television broadcast signal, a display unit that displays a picture represented by the video signal acquired by the broadcast receiving unit, a loudspeaker that outputs sounds represented by the audio signal acquired by the broadcast receiving unit, and a user operating unit which a user uses to designate an external audio output mode in which the sounds represented by the audio signal acquired by the broadcast receiving unit are outputted through the external loudspeaker may be further included. The communication unit may feed the audio signal acquired by the broadcast receiving unit to the another electronic equipment, and may transmit the designating information on the external output mode entered using the user operating unit. In this case, the audio signal acquired by the broadcast receiving unit can be sent to the another electronic equipment side. The sounds represented by the audio signal acquired by the broadcast receiving unit can be outputted through the external loudspeaker according to the user's designation of the external audio output mode.

In the invention, for example, a remote control signal receiving unit that receives a remote control signal (remote control code) sent from a transmitter of the remote control signal may be further included. The communication unit may transmit the remote control signal received by the remote control signal receiving unit to another electronic equipment. In this case, when a user remotely controls the another electronic equipment side, the communication unit can send a remote control signal deriving from the remote control to the another electronic equipment side. The operating state of the another electronic equipment side can be quickly controlled.

The concept of the invention lies in electronic equipment that includes a signal transmitting unit which transmits a video signal to another electronic equipment over a transmission line by means of differential signals on multiple channels, and that further includes:

a communication unit that performs bidirectional communication using predetermined lines included in the transmission line; and

a control unit that controls the operating state on the basis of control information received by the communication unit.

The electronic equipment of the invention includes the signal transmitting unit that transmits a video signal to another electronic equipment over a transmission line by means of differential signals on multiple channels, and is, for example, HDMI-conformable source equipment or repeater equipment. In the invention, the communication unit that performs bidirectional communication using predetermined lines included in the transmission line is included. The control unit controls the operating state on the basis of the control information received by the communication unit. In this case, the control information can be quickly received from the another electronic equipment, and quick control of the operating state from the another electronic equipment side is permitted.

In the invention, for example, a broadcast receiving unit that acquires a video signal on a predetermined channel on the basis of a television broadcast signal, and a recording unit that records the video signal acquired by the broadcast receiving unit may be included. The control unit may control a channel, which is selected by the broadcast receiving unit, on the basis of information on channel selection received by the communication unit, and may also control the recording unit on the basis of the information on recording instruction, which is received by the communication unit, so that the recording unit will initiate recording of the video signal acquired by the broadcast receiving unit. In this case, the channel selected by the broadcast receiving unit can be switched to the channel relevant to the picture displayed on the display unit existing on the another electronic equipment side. When user's recording instruction is made on the another electronic equipment side, the recording unit can immediately initiate recording of the video signal representing the picture displayed on the display unit on the another electronic equipment side.

In the invention, for example, an audio output unit that outputs an audio signal received by the communication unit to the loudspeaker may be further included. The control unit may control the audio output unit on the basis of the designating information on the external audio output mode, which is received by the communication unit, so that muting in the audio output unit will be changed from an on state to an off state. In this case, the audio signal acquired by the broadcast receiving unit on the another electronic equipment side can be received. When the user's designating information on the external audio output mode is fed from the another electronic equipment side, muting in the audio output unit is changed from the on state to the off state. Control can be immediately implemented in order to attain a state in which sounds represented by the audio signal acquired by the broadcast receiving unit on the another electronic equipment side can be outputted through the external loudspeaker.

In the invention, for example, the control unit may control the actions of the respective units on the basis of a remote control signal received by the communication unit. In this case, the remote control signal is transmitted from another electronic equipment side, and the actions of the respective units can be quickly controlled.

Advantage of the Invention

According to the invention, a communication unit that performs bidirectional communication using predetermined lines included in a transmission line is included. The communication unit is used to transmit control information to another electronic equipment. The operating state of the another electronic equipment can be quickly controlled. According to the invention, a communication unit that performs bidirectional communication using predetermined lines included in a transmission line is included. The communication unit is used to receive control information from another electronic equipment. An operating state is controlled based on the control information. The operating state can be quickly controlled from the another electronic equipment side.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing as an embodiment an example of the configuration of a communication system employing the HDMI;

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FIG. 2 is a block diagram showing an example of the configuration of a television receiver serving as sink equipment;

FIG. 3 is a diagram showing the construction of an IP packet to be used to transmit a remote control code;

FIG. 4 is a block diagram showing an example of the configuration of an audio amplifier serving as repeater equipment;

FIG. 5 is a block diagram showing an example of the configuration of a DVD recorder serving as source equipment;

FIG. 6 is a block diagram showing an example of arrangement of an HDMI transmitting unit (HDMI source) and an HDMI receiving unit (HDMI sink);

FIG. 7 is a diagram showing the structure of TMDS transmission data;

FIG. 8 is a diagram showing the pin assignment (type A) of an HDMI terminal;

FIG. 9 is a connection diagram showing an example of arrangement of a high-speed data line interface 103 of a television receiver 100 and a high-speed data line interface 203a of an audio amplifier 200;

FIG. 10 is a diagram for explaining a “one-touch recording” sequence of recording a picture (image), which is seen on the television receiver 100, with a DVD recorder 300;

FIG. 11 is a diagram showing as a comparative example a “one-touch recording” sequence to be employed in a case where a high-speed data line interface is not included;

FIG. 12 is a diagram for explaining a “theater mode” sequence of switching audio outputs between the television receiver 100 and audio amplifier 200;

FIG. 13 is a diagram showing as a comparative example a “theater mode” sequence to be employed in a case where a high-speed data line interface is not included;

FIG. 14 is a diagram for explaining a “remote control” sequence; and

FIG. 15 is a diagram showing as a comparative example a “remote control” sequence to be employed in a case where a high-speed data line interface is not included.

DESCRIPTION OF REFERENCE NUMERALS

10: communication system, 100: television receiver, 101: HDMI terminal, 102: HDMI receiving unit, 103: high-speed data line interface, 200: audio amplifier, 201a, 201b: HDMI terminal, 202a: HDMI transmitting unit, 202b: HDMI receiving unit, 203a, 203b: high-speed data line interface, 300: DVD recorder, 301: HDMI terminal, 302: HDMI transmitting unit, 303: high-speed data line interface, 400: receiving antenna, 500: 5.1-channel loudspeaker group, 610, 620: HDMI cable.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to the drawings, an embodiment of the invention will be described below. FIG. 1 shows an example of the configuration of a communication system 10 as an embodiment. The communication system 10 includes a television receiver 100 serving as sink equipment, an audio amplifier 200 serving as repeater equipment, and a DVD recorder 300 serving as source equipment. To the television receiver 100 and DVD recorder 300, a television broadcast receiving antenna 400 is connected. To the audio amplifier 200, a 5.1-channel loudspeaker group 500 is connected.

The television receiver 100 and audio amplifier 200 are interconnected over an HDMI cable 610. The television

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receiver 100 is provided with an HDMI terminal 101 to which an HDMI receiving unit (HDMIRX) 102 and a high-speed data line interface (I/F) 103 included in a communication unit are connected. The audio amplifier 200 is provided with an HDMI terminal 201a to which an HDMI transmitting unit (HDMITX) 202a and a high-speed data line interface (I/F) 203a included in a communication unit are connected. One end of the HDMI cable 610 is coupled to the HDMI terminal 101 of the television receiver 100, and the other end of the HDMI cable 610 is coupled to the HDMI terminal 201a of the audio amplifier 200.

The audio amplifier 200 and DVD recorder 300 are interconnected over a HDMI cable 620. The audio amplifier 200 is provided with an HDMI terminal 201b to which an HDMI receiving unit (HDMIRX) 202b and a high-speed data line interface (I/F) 203b included in a communication unit are connected. The DVD recorder 300 is provided with an HDMI terminal 301 to which an HDMI transmitting unit (HDMITX) 302 and a high-speed data line interface (I/F) 303 included in a communication unit are connected. One end of the HDMI cable 620 is coupled to the HDMI terminal 201b of the audio amplifier 200, and the other end of the HDMI cable 620 is coupled to the HDMI terminal 301 of the DVD recorder 300.

FIG. 2 shows an example of the configuration of the television receiver 100. The television receiver 100 includes the HDMI terminal 101, the HDMI receiving unit 102, the high-speed data line interface 103, an antenna terminal 105, a digital tuner 106, a demultiplexer 107, a moving picture expert group (MPEG) decoder 108, a video signal processing circuit 109, a graphic production circuit 110, a panel drive circuit 111, a display panel 112, an audio signal processing circuit 113, an audio amplification circuit 114, a loudspeaker 115, a digital transmission content protection (DTCP) circuit 116, an internal bus 120, a central processing unit (CPU) 121, a flash read-only memory (ROM) 122, a dynamic random access memory (DRAM) 123, an Ethernet interface (I/F) 124, a network terminal 125, a remote control receiving unit 126, and a remote control transmitter 127.

Noted is that “Ethernet” is a registered trademark. The digital tuner 106 and demultiplexer 107 constitute a broadcast receiving unit. The remote control receiving unit 126 and remote control transmitter 127 constitute a user operating unit.

The antenna terminal 105 is a terminal that inputs a television broadcast signal received by the receiving antenna 400. The digital tuner 106 processes the television broadcast signal inputted to the antenna terminal 105, and outputs a predetermined transport stream associated with a user-selected channel. The demultiplexer 107 extracts a partial transport stream (TS) (a TS packet of video data and a TS packet of audio data) from the transport stream obtained by the digital tuner 106.

The demultiplexer 107 fetches a program-specific information/service information (PSI/SI) from the transport stream obtained by the digital tuner 106, and outputs the PSI/SI to the CPU 121. The transport stream obtained by the digital tuner 106 has multiple channels multiplexed therein. The processing in which the demultiplexer 107 extracts the partial TS on an arbitrary channel from the transport stream is enabled by obtaining information concerning a packet ID (PID) on the arbitrary channel from the PSI/SI (PAT/PMT).

The MPEG decoder 108 performs decoding processing on a video packetized elementary stream (PES) packet formed with a TS packet of video data obtained by the demultiplexer 107 so as to provide video data. The MPEG decoder 108 performs decoding processing on an audio PES packet formed with a TS packet of audio data obtained by the demultiplexer 107 so as to provide audio data. The MPEG decoder

108 performs decoding processing on the PES packets of a picture and sounds respectively, which are decrypted by the DTCP circuit **116**, so as to provide video data and audio data.

The video signal processing circuit **109** and graphic production circuit **110** perform, if necessary, multi-screen processing, graphic data superposing processing, or the like on video data obtained by the MPEG decoder **108**. The panel drive circuit **111** drives the display panel **112** on the basis of the video data outputted from the graphic production circuit **110**. The display panel **112** is formed with, for example, a liquid crystal display (LCD), a plasma display panel (PDP), or the like. The audio signal processing circuit **113** performs required processing such as D/A conversion on the audio data obtained by the MPEG decoder **108**. The audio amplification circuit **114** amplifies an audio signal outputted from the audio signal processing circuit **113**, and feeds the resultant signal to the loudspeaker **115**.

The DTCP circuit **116** encrypts, if necessary, a partial TS extracted by the demultiplexer **107**. The DTCP circuit **116** decrypts encrypted data fed from the network terminal **125** or high-speed data line interface **103** to the Ethernet interface **124**.

The CPU **121** controls the actions of the components of the television receiver **100**. The flash ROM **122** stores control software and preserves data. The DRAM **123** forms a work area for the CPU **121**. The CPU **121** develops software or data, which is read from the flash ROM **122**, in the DRAM **123**, activates the software, and controls the components of the television receiver **100**. The remote control receiving unit **126** receives a remote control signal (remote control code) transmitted from the remote control transmitter **127**, and feeds the signal to the CPU **121**. The CPU **121**, flash ROM **122**, DRAM **123**, and Ethernet interface **124** are interconnected over the internal bus **120**.

The HDMI receiving unit (HDMI sink) **102** receives video (image) data and audio data of the baseband fed to the HDMI terminal **101** over the HDMI cable **610** through the communication in accordance with the HDMI. The HDMI receiving unit **102** will be detailed later. The high-speed data line interface **103** is a bidirectional communication interface employing predetermined lines (in this embodiment, a reserved line and an HPD line) included in the HDMI cable **610**. The high-speed data line interface **103** will be detailed later.

The actions in the television receiver **100** shown in FIG. 2 will be briefly described below.

A television broadcast signal inputted to the antenna terminal **105** is fed to the digital tuner **106**. The digital tuner **106** processes the television broadcast signal, and outputs a predetermined transport stream associated with a user-selected channel. The predetermined transport stream is fed to the demultiplexer **107**. The demultiplexer **107** extracts a partial TS (a TS packet of video data and a TS packet of audio data) associated with the user-selected channel from the transport stream. The partial TS is fed to the MPEG decoder **108**.

The MPEG decoder **108** performs decoding processing on a video PES packet formed with the TS packet of video data, and provides the video data. The video data is subjected to, if necessary, multi-screen processing, graphic data superposing processing, or the like by the video signal processing circuit **109** and graphic production circuit **110**. Thereafter, the resultant video data is fed to the panel drive circuit **111**. An image associated with the user-selected channel is displayed on the display panel **112**.

The MPEG decoder **108** performs decoding processing on an audio PES packet formed with the TS packet of audio data, and provides the audio data. The audio data is subjected to required processing such as D/A conversion by the audio

signal processing circuit **113**. After amplified by the audio amplification circuit **114**, the resultant audio data is fed to the loudspeaker **115**. Sounds associated with the user-selected channel are outputted through the loudspeaker **115**.

When the television broadcast signal is received, a partial TS extracted by the demultiplexer **107** is encrypted by the DTCP circuit **116**, and fed as transmitted data to the high-speed data line interface **103** via the Ethernet interface **124**. Therefore, the partial TS is transmitted to the audio amplifier **200** over the predetermined lines of the HDMI cable **610** coupled to the HDMI terminal **101**.

When the television broadcast signal is received, if the partial TS extracted by the demultiplexer **107** is transmitted over a network, after the partial TS is encrypted by the DTCP circuit **116**, the resultant partial TS is outputted to the network terminal **125** via the Ethernet interface **124**.

The remote control receiving unit **126** receives a remote control code (remote control signal) sent from the remote control transmitter **127**. The remote control code is fed to the CPU **121**. If the remote control code relates to control of the television receiver **100**, the CPU **121** controls the components of the television receiver **100** on the basis of the remote control code.

The CPU **121** produces an IP packet containing the remote control code fed from the remote control receiving unit **126**. The IP packet is outputted to the HDMI terminal **101** via the Ethernet interface **124** and high-speed data line interface **103**. The IP packet is transmitted to the audio amplifier **200** side over the HDMI cable **610** coupled to the HDMI terminal **101**. The IP packet is, if necessary, transmitted over a network. In this case, the IP packet is outputted to the network terminal **125** via the Ethernet interface **124**.

FIG. 3 shows the construction of an IP packet containing a remote control code. The IP packet is composed of an IP header, a payload, and a CRC. In the IP packet containing the remote control code, the remote control code is inserted into the payload division.

After an encrypted partial TS that is fed from the network terminal **125** to the Ethernet interface **124** or fed from the HDMI terminal **101** to the Ethernet interface **124** via the high-speed data line interface **103** is decrypted by the DTCP circuit **116**, the decrypted partial TS is fed to the MPEG decoder **108**. Thereafter, the same actions as those performed when a television broadcast signal is received are carried out. An image is displayed on the display panel **112**, and sounds are outputted through the loudspeaker **115**.

The HDMI receiving unit **102** acquires video (image) data and audio data that are transmitted from the audio amplifier **200** side connected to the HDMI terminal **101** over the HDMI cable **610**. The video data and audio data are fed to the video signal processing circuit **109** and audio signal processing circuit **113** respectively. Thereafter, the same actions as those performed when a television broadcast signal is received are carried out. An image is displayed on the display panel **112**, and sounds are outputted through the loudspeaker **115**.

FIG. 4 shows an example of the configuration of the audio amplifier **200**. The audio amplifier **200** includes the HDMI terminals **201a** and **201b**, the HDMI transmitting unit **202a**, the HDMI receiving unit **202b**, the high-speed data line interfaces **203a** and **203b**, an MPEG decoder **204**, a video/graphic processing circuit **205**, an audio processing circuit **207**, an audio amplification circuit **208**, audio output terminals **209a** to **209e**, a DTCP circuit **210**, an Ethernet interface **211**, an internal bus **212**, a CPU **213**, a flash ROM **214**, and a DRAM **215**.

The HDMI transmitting unit (HDMI source) **202a** transmits video (image) data and audio data of the baseband from

the HDMI terminal **201a** over the HDMI cable **610** through communication conformable to the HDMI. The HDMI receiving unit (HDMI sink) **202b** receives video (image) data and audio data of the baseband fed to the HDMI terminal **201b** over the HDMI cable **620** through communication conformable to the HDMI. The HDMI transmitting unit **202a** and HDMI receiving unit **202b** will be detailed later.

The high-speed data line interface **203a** is a bidirectional communication interface using predetermined lines (in the present embodiment, a reserved line and an HPD line) included in the HDMI cable **610**. The high-speed data line interface **203b** is a bidirectional communication interface using predetermined lines (in the present embodiment, a reserved line and an HPD line) included in the HDMI cable **620**. The high-speed data line interfaces **203a** and **203b** will be detailed later.

The DTCP circuit **210** decrypts an encrypted partial TS that is fed to the Ethernet interface **211** via the high-speed data line interface **203b**. The MPEG decoder **204** performs decoding processing on an audio PES packet out of the partial TS decrypted by the DTCP circuit **210**, and thus provides audio data.

The audio processing circuit **207** performs required processing such as D/A conversion on the audio data obtained by the MPEG decoder **204**. The audio amplification circuit **208** amplifies a front left audio signal SFL, a front right audio signal SFR, a front center audio signal SFC, a rear left audio signal SRL, and a rear right audio signal SRR, and outputs the resultant signals to the audio output terminals **209a**, **209b**, **209c**, **209d**, and **209e** respectively.

A front left loudspeaker **500a**, a front right loudspeaker **500b**, a front center loudspeaker **500c**, a rear left loudspeaker **500d**, and a rear right loudspeaker **500e** constituting the loudspeaker group **500** are connected to the audio output terminals **209a**, **209b**, **209c**, **209d**, and **209e** respectively.

The audio processing circuit **207** performs required processing on the audio data obtained by the HDMI receiving unit **202b**, and then feeds the resultant audio data to the HDMI transmitting unit **202a**. The video/graphic processing circuit **205** performs processing such as graphic data superposition on the video (image) data obtained by the HDMI receiving unit **202b**, and then feeds the resultant data to the HDMI transmitting unit **202a**.

The CPU **213** controls the actions of the components of the audio amplifier **200**. The flash ROM **204** stores control software and preserves data. The DRAM **215** forms a work area for the CPU **213**. The CPU **213** develops software and data, which are read from the flash ROM **214**, in the DRAM **215**, activates the software, and controls the components of the audio amplifier **200**. The CPU **213**, flash ROM **214**, DRAM **215**, and Ethernet interface **211** are interconnected over the internal bus **212**.

The actions in the audio amplifier **200** shown in FIG. 4 will be briefly described below.

In the HDMI receiving unit **202b**, video (image) data and audio data sent from the DVD recorder **300** connected to the HDMI terminal **201b** over the HDMI cable **620** are acquired. The video data and audio data are fed to the HDMI transmitting unit **202a** via the video/graphic processing circuit **205** and audio processing circuit **207** respectively, and transmitted to the television receiver **100** over the HDMI cable **610** coupled to the HDMI terminal **201a**.

In the high-speed line interface **203a**, an encrypted partial TS transmitted from the television receiver **100** over predetermined lines of the HDMI cable **610** coupled to the HDMI

terminal **201a** is received. The partial TS is fed to the DTCP circuit **210** via the Ethernet interface **211**, and decrypted thereby.

The partial TS decrypted by the DTCP circuit **210** is fed to the MPEG decoder **204**. In the MPEG decoder **204**, decoding processing is performed on a PES packet of audio data included in the partial TS in order to provide the audio data. The audio data is fed to the audio processing circuit **207** and subjected to required processing such as D/A conversion. When muting is set to an off state, various audio signals SFL, SFR, SFC, SRL, and SRR outputted from the audio processing circuit **207** are amplified and outputted to the audio output terminals **209a**, **209b**, **209c**, **209d**, and **209e** respectively. Sounds are outputted through the loudspeaker group **500**.

In the high-speed data line interface **203a**, an IP packet containing a remote control code and being transmitted from the television receiver **100** over predetermined lines of the HDMI cable **610** coupled to the HDMI terminal **201a** is received. The IP packet is fed to the CPU **213** via the Ethernet interface **211**. When the remote control code contained in the IP packet relates to control of the audio amplifier **200**, the CPU **213** controls the components of the audio amplifier **200** on the basis of the remote control code. For example, when the remote control code represents a designation of a "theater mode" as an external audio output mode, the CPU **213** controls muting of the audio amplification circuit **208** so that the muting will be changed from the on state to an off state.

The partial TS and IP packet received as mentioned above by the high-speed data line interface **203a** and fed to the Ethernet interface **211** are fed as transmitted data to the high-speed data line interface **203b**. The partial TS and IP packet are transmitted to the DVD recorder **300** over predetermined lines of the HDMI cable **620** coupled to the HDMI terminal **201b**.

FIG. 5 shows an example of the configuration of the DVD recorder **300**. The DVD recorder **300** includes the HDMI terminal **301**, the HDMI transmitting unit **302**, the high-speed data line interface **303**, an antenna terminal **304**, a digital tuner **305**, a demultiplexer **306**, an internal bus **307**, a recording unit interface **308**, a DVD/BD drive **309**, a hard disk drive (HDD) **310**, a CPU **311**, a flash ROM **312**, a DRAM **313**, an Ethernet interface **314**, a network terminal **315**, a DTCP circuit **316**, an MPEG decoder **317**, a graphic production circuit **318**, a video output terminal **319**, and an audio output terminal **320**. The digital tuner **305** and demultiplexer **306** constitute a broadcast receiving unit.

The HDMI transmitting unit (HDMI source) **302** transmits video (image) data and audio data of the baseband from the HDMI terminal **301** over the HDMI cable **620** through communication conformable to the HDMI. The HDMI transmitting unit **302** will be detailed later.

The high-speed data line interface **303** is a bidirectional communication interface using predetermined lines (in the present embodiment, a reserved line and an HPD line) included in the HDMI cable **620**. The high-speed data line interface **303** will be detailed later.

The antenna terminal **304** is a terminal that inputs a television broadcast signal received by the receiving antenna **400**. The digital tuner **305** processes the television broadcast signal inputted to the antenna terminal **304** and outputs a predetermined transport stream. The demultiplexer **306** extracts a partial transport stream (TS) (a TS packet of video data and a TS packet of audio data), which is associated with a predetermined selected channel, from the transport stream obtained by the digital tuner **305**.

The demultiplexer **306** fetches program-specific information/service information (PSI/SI) from the transport stream

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obtained by the digital tuner **305**, and outputs the PSI/SI to the CPU **311**. In the transport stream obtained by the digital tuner **305**, multiple channels are multiplexed. The processing in which the demultiplexer **306** extracts the partial TS on an arbitrary channel from the transport stream is enabled by acquiring information concerning a packet ID (PID) on the arbitrary channel from the PSI/SI (PAT/PMT).

The CPU **311**, flash ROM **312**, DRAM **313**, demultiplexer **306**, Ethernet interface **314**, and recording unit interface **308** are interconnected over the internal bus **307**. The DVD/BD drive **309** and HDD **310** are connected onto the internal bus **307** via the recording unit interface **308**. The DVD/BD drive **309** and HDD **310** record the partial TS extracted by the demultiplexer **306**. The DVD/BD drive **309** and HDD **310** reproduce the partial TS recorded in a recording medium.

The MPEG decoder **317** performs decoding processing on a video PES packet, which is included in the partial TS extracted by the demultiplexer **306** or reproduced by the DVD/BD drive **309** and HDD **310**, and provides video data. The MPEG decoder **317** performs decoding processing on an audio PES packet included in the partial TS, and provides audio data.

The graphic production circuit **318** performs, if necessary, graphic data superposing processing or the like on the video data obtained by the MPEG decoder **317**. The video output terminal **319** outputs the video data that is outputted from the graphic production circuit **318**. The audio output terminal **320** outputs the video data obtained by the MPEG decoder **317**.

The DTCP circuit **316** encrypts, if necessary, the partial TS extracted by the demultiplexer **306** or the partial TS reproduced by the DVD/BD drive **309** and HDD **310**. The DTCP circuit **316** decrypts the encrypted data fed from the network terminal **315** or high-speed data line interface **303** to the Ethernet interface **314**.

The CPU **311** controls the actions of the components of the DVD recorder **300**. The flash ROM **312** stores control software and preserves data. The DRAM **313** forms a work area for the CPU **311**. The CPU **311** develops software and data, which are read from the flash ROM **312**, in the DRAM **313**, activates the software, and controls the components of the DVD recorder **300**.

The actions in the DVD recorder **300** shown in FIG. 5 will be briefly described below.

A television broadcast signal inputted to the antenna terminal **304** is fed to the digital tuner **305**. In the digital tuner **305**, a predetermined transport stream is fetched by processing the television broadcast signal, and the predetermined transport stream is fed to the demultiplexer **306**. In the demultiplexer **306**, a partial TS (a TS packet of video data and a TS packet of audio data) associated with a predetermined channel is extracted from the transport stream. The partial TS is fed to the DVD/BD drive **309** or HDD **310** via the recording unit interface **308**, and recorded based on a recording instruction sent from the CPU **311**.

The partial TS extracted by the demultiplexer **306** or the partial TS reproduced by the DVD/BD drive **309** or HDD **310** is fed to the MPEG decoder **317**. In the MPEG decoder **317**, decoding processing is performed on a video PES packet formed with a TS packet of video data in order to obtain video data. The video data is subjected to graphic data superposing processing or the like by the graphic production circuit **318**, and then outputted to the video output terminal **319**. In the MPEG decoder **317**, decoding processing is performed on an audio PES packet formed with a TS packet of audio data in order to obtain audio data. The audio data is outputted to the audio output terminal **320**.

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The video (image) data and audio data obtained by the MPEG decoder **317** according to the partial TS reproduced by the DVD/BD drive **309** or HDD **310** are fed to the HDMI transmitting unit **302**, and transmitted to the audio amplifier **200** over the HDMI cable **620** coupled to the HDMI terminal **302**.

In the high-speed data line interface **303**, an encrypted partial TS transmitted from the audio amplifier **200** side over predetermined lines of the HDMI cable **620** coupled to the HDMI terminal **301** is received. The partial TS is fed to the DTCP circuit **316** via the Ethernet interface **314**, and decrypted thereby.

The partial TS decrypted by the DTCP circuit **316** is fed to the CPU **311**. The CPU **311** analyzes the partial TS, and extracts a packet ID (PID) serving as channel selection information signifying what channel is selected in the television receiver **100**. The CPU **311** controls the digital tuner **305** and demultiplexer **306** on the basis of the packet ID, and permits selection of the same channel as the channel in the television receiver **100**. In this case, when the channel selected in the television receiver **100** is changed to another, the channel selected in the DVD recorder **300** is also changed to another.

In the high-speed data line interface **303**, an IP packet containing a remote control code and being transmitted from the audio amplifier **200** side over predetermined lines of the HDMI cable **620** coupled to the HDMI terminal **301** is received. The IP packet is fed to the CPU **311** via the Ethernet interface **314**. When the remote control code contained in the IP packet relates to control of the DVD recorder **300**, the CPU **311** controls the components of the DVD recorder **300** on the basis of the remote control code.

For example, when the remote control code is what instructs recording, the CPU **311** implements control so that the partial TS extracted by the demultiplexer **306** will be recorded by the DVD/BD drive **309** or HDD **310**.

When the partial TS extracted by the demultiplexer **306** or the partial TS reproduced by the DVD/BD drive **309** or HDD **310** is transmitted over a network, after the partial TS is encrypted by the DTCP circuit **316**, the resultant partial TS is outputted to the network terminal **315** via the Ethernet interface **314**.

FIG. 6 shows an example of the arrangement in the communication system **10** shown in FIG. 1 of the HDMI receiving unit (HDMI sink) **102** of the television receiver **100** and the HDMI transmitting unit (HDMI source) **202a** of the audio amplifier **200**.

The HDMI transmitting unit **202a** unidirectionally transmits differential signals of the baseband (non-compressed), which represent image data for one screen, to the HDMI receiving unit **102** on multiple channels during an effective image interval (hereinafter, referred to as an active video interval) that is an interval having a horizontal blanking period and a vertical blanking period excluded from an interval from a certain vertical synchronizing signal to the next vertical synchronizing signal (hereinafter, referred to as a video field). During the horizontal blanking period and vertical blanking period, the HDMI transmitting unit **202a** unidirectionally transmits differential signals, which represent audio data, a control packet, and other auxiliary data that accompany image data, to the HDMI receiving unit **102** on multiple channels.

The HDMI transmitting unit **202a** includes a source signal processing block **71** and an HDMI transmitter **72**. To the source signal processing block **71**, non-compressed image (video) data and audio data of the baseband are fed. The source signal processing block **71** performs required processing on the fed image data and audio data, and feeds the

resultant image data and audio data to the HDMI transmitter **72**. The source signal processing block **71** transfers, if necessary, control information or information indicating a status (control/status), to or from the HDMI transmitter **72**.

The HDMI transmitter **72** converts the image data, which is fed from the source signal processing block **71**, into differential signals, and unidirectionally transmits the differential signals to the HDMI receiving unit **102**, which is connected over the HDMI cable **610**, on multiple channels, that is, three TMDS channels #0, #1, and #2.

The transmitter **72** converts audio data, a control packet, or any other auxiliary data accompanying non-compressed image data, and control data items of a vertical synchronizing signal (VSYNC) and a horizontal synchronizing signal (HSYNC), which are fed from the source signal processing block **71**, into differential signals, and unidirectionally transmits the differential signals to the HDMI receiving unit **102**, which is connected over the HDMI cable **610**, on the three TMDS channels #0, #1, and #2.

The transmitter **72** transmits a pixel clock, which is synchronous with image data items to be transmitted on the three TMDS channels #0, #1, and #2, to the HDMI receiving unit **102**, which is connected over the HDMI cable **610**, on a TMDS clock channel.

The HDMI receiving unit **102** receives differential signals, which represent image data items and are unidirectionally transmitted from the HDMI transmitting unit **202a** on multiple channels, during an active video interval, and also receives differential signals, which represent auxiliary data and control data items and are transmitted from the HDMI transmitting unit **202a** on multiple channels, during the horizontal blanking period and vertical blanking period.

The HDMI receiving unit **102** includes an HDMI receiver **81** and a sink signal processing block **82**. The HDMI receiver **81** receives the differential signals, which represent image data items and are unidirectionally transmitted from the HDMI transmitting unit **202a**, which is connected over the HDMI cable **610**, on the TMDS channels #0, #1, and #2, and the differential signals, which represent the auxiliary data and control data items, synchronously with the pixel clock transmitted on the TMDS clock channel from the HDMI transmitting unit **202a**. Further, the HDMI receiver **81** converts the differential signals into the representative image data items, auxiliary data, and control data items, and feeds, if necessary, the data items to the sink signal processing block **82**.

The sink signal processing block **82** performs required processing on the data items fed from the HDMI receiver **81**, and outputs the resultant data items. The sink signal processing block **82** transfers, if necessary, control information and information indicating a status (control/status) to or from the HDMI receiver **81**.

The HDMI transmission channels include, in addition to the three TMDS channels #0, #1, and #2 on which image data items, auxiliary data, and control data items are unidirectionally serially transmitted from the HDMI transmitting unit **202a** to the HDMI receiving unit **102** synchronously with the pixel clock, and the TMDS clock channel serving as a transmission channel on which the pixel clock is transmitted, transmission channels called a display data channel (DDC) **83** and a CEC line **84**.

The DDC **83** is realized with two lines (signal lines) that are included in the HDMI cable **610** and are not shown, and is used when source equipment reads enhanced-extended display identification (E-EDID) from sink equipment connected over the HDMI cable **610**. Namely, the sink equipment includes an EDIDROM **85**. The source equipment reads the E-EDID, which is stored in the EDIDROM **85**, from the sink

equipment, which is connected over the HDMI cable **610**, over the DDC **83**, and recognizes the settings and performance of the sink equipment on the basis of the E-EDID.

The CEC line **84** is formed with one line that is included in the HDMI cable **610** and is not shown, and is used to perform bidirectional communication of control data items between source equipment and sink equipment.

The HDMI cable **620** includes a line **86** coupled to a pin called Hot Plug Detect (HPD). Source equipment can detect connection of sink equipment by utilizing the line **86**. A line **87** to be used to supply power from source equipment to sink equipment is further included in the HDMI cable **620**. A reserved line **88** is further included in the HDMI cable **610**.

FIG. 7 shows an example of transmission intervals (periods) during which various kinds of transmission data items are transmitted on the three TMDS channels #0, #1, and #2 conformable to the HDMI. FIG. 7 shows the intervals for the various kinds of transmission data items to be transmitted in a case where a progressive image of 720 pixels sideways×480 pixels lengthwise is transmitted on the TMDS channels #0, #1, and #2.

Within a video field during which transmitted data items are transmitted on the three TMDS channels #0, #1, and #2 conformable to the HDMI, three intervals of a video data interval (video data period), a data island interval (data island period), and a control interval (control period) are defined.

The video field interval is an interval from the leading edge (active edge) of a certain vertical synchronizing signal to the leading edge of the next vertical synchronizing signal, and is divided into a horizontal blanking period (horizontal blanking), a vertical blanking period (vertical blanking), and an active video interval (active video) that is an interval having the horizontal blanking period and vertical blanking period removed from the video field interval.

The video data interval is allocated to the active video interval. Within the video data interval, effective pixels (active pixel) corresponding to a product of 720 pixels×480 lines and constituting non-compressed image data items for one screen are transmitted during the video data interval.

The data island interval and control interval are allocated to the horizontal blanking period and vertical blanking period. During the data island interval and control interval, auxiliary data is transmitted.

Specifically, the data island interval is allocated to parts of the horizontal blanking period and vertical blanking periods. During the data island interval, data out of the auxiliary data that does not relate to control, for example, a packet of audio data is transmitted.

The control interval is allocated to the other parts of the horizontal blanking period and vertical blanking period. During the control interval, data out of the auxiliary data that does not relate to control, for example, a vertical synchronizing signal, a horizontal synchronizing signal, and a control packet are transmitted.

According to the ongoing HDMI, the frequency of a pixel clock to be transmitted on the TMDS clock channel is, for example, 165 MHz. In this case, the transfer rate for the data island interval is on the order of approximately 500 Mbps.

FIG. 8 shows the pin assignments of the HDMI terminals **101** and **201a** respectively. The pin assignments are called type A assignments.

Two lines that are differential lines over which differential signals TMDS Data#i+ and TMDS Data#i- on the TMDS channel #i are transmitted are coupled to a pin (any of pins whose pin numbers are 1, 4, and 7) to which TMDS Data#i+ is assigned, and a pin (any of pins whose pin numbers are 3, 6, and 9) to which TMDS Data#i- is assigned.

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The CEC line **84** over which a CEC signal representing control data is transmitted is coupled to a pin whose pin number is 13. A pin whose pin number is 14 is an unused (reserved) pin. A line over which a serial data (SDA) signal such as F-EDID is transmitted is coupled to a pin whose pin number is 16. A line over which a serial clock (SCL) signal that is a clock signal to be used for synchronization at the time of transmitting or receiving the SDA signal is transmitted is coupled to a pin whose pin number is 15. The DDC **83** is formed with the line over which the SDA signal is transmitted and the line over which the SCL signal is transmitted.

The line **86** which the source equipment **110** uses, as mentioned above, to detect connection of the sink equipment **120** is coupled to a pin whose pin number is 19. The line **87** to be used to, as mentioned above, supply power is coupled to a pin whose pin number is 18.

FIG. 6 shows an example of the arrangement in the communication system **10** shown in FIG. 1 of the HDMI transmitting unit (HDMI source) **202a** of the audio amplifier **200** and the HDMI receiving unit (HDMI sink) **102** of the television receiver **100**. The HDMI transmitting unit **302** of the DVD recorder **300** and the HDMI receiving unit **202b** of the audio amplifier **200** in the communication system **10** shown in FIG. 1 are arranged in the same manner, though a detail will be omitted.

FIG. 9 shows an example of the arrangement in the communication system **10** shown in FIG. 1 of the high-speed data line interface **103** of the television receiver **100** and the high-speed data line interface **203a** of the audio amplifier **200**. The interfaces **103** and **203a** constitute a communication unit that performs local-area network (LAN) communication. The communication unit performs communication using a pair of differential lines out of the multiple lines constituting the HDMI cable **610**, that is, in the present embodiment, a reserved line (Ether-line) coupled to an unused (reserve) pin (14 pin) and an HPD line (Ether+line) coupled to an HPD pin (19 pin).

The audio amplifier **200** includes a LAN signal transmission circuit **411**, a terminal resistor **412**, ac-coupling capacitors **413** and **414**, a LAN signal reception circuit **415**, a subtraction circuit **416**, a pull-up resistor **421**, a resistor **422** and a capacitor **423** constituting a low-pass filter, a comparator **424**, a pull-down resistor **431**, a resistor **432** and a capacitor **433** constituting a low-pass filter, and a comparator **434**. Herein, the high-speed data line interface **203a** is composed of the LAN signal transmission circuit **411**, terminal resistor **412**, ac-coupling capacitors **413** and **414**, LAN signal reception circuit **415**, and subtraction circuit **416**.

Between a power line (+5.0 V) and a ground line, a series circuit composed of the pull-up resistor **421**, ac-coupling capacitor **413**, terminating resistor **412**, ac-coupling capacitor **414**, and pull-down resistor **431** is connected. A junction point P1 between the ac-coupling capacitor **413** and terminating resistor **412** is connected to the positive output side of the LAN signal transmission circuit **411**, and also connected to the positive input side of the LAN signal reception circuit **415**. A junction point P2 between the ac-coupling capacitor **414** and terminating resistor **412** is connected to the negative output side of the LAN signal transmission circuit **411**, and also connected to the negative input side of the LAN signal reception circuit **415**. To the input side of the LAN signal transmission circuit **411**, a transmitted signal SG **411** is fed from the Ethernet interface **211**.

To the positive terminal of the subtraction circuit **416**, an output signal SG**412** of the LAN signal reception circuit **415** is fed. To the negative terminal of the subtraction circuit **416**, the transmitted signal SG**411** is fed from the Ethernet inter-

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face **211**. In the subtraction circuit **416**, the transmitted signal SG**411** is subtracted from the output signal SG**412** of the LAN signal reception circuit **415**. The output signal SG**413** of the subtraction circuit **416** is fed to the Ethernet interface **211**.

A junction point Q1 between the pull-up resistor **421** and ac-coupling capacitor **413** is connected to the ground line via the series circuit composed of the resistor **422** and capacitor **423**. An output signal of the low-pass filter developed at the junction point between the resistor **422** and capacitor **423** is fed to one of the input terminals of the comparator **424**. In the comparator **424**, the output signal of the low-pass filter is compared with a reference voltage Vref1 (+3.75 V) fed to the other input terminal. An output signal SG**414** of the comparator **424** is fed to the CPU **213** (not shown).

A junction point Q2 between the ac-coupling capacitor **414** and pull-down resistor **431** is connected to the ground line via the series circuit of the resistor **432** and capacitor **433**. An output signal of the low-pass filter developed at the junction point between the resistor **432** and capacitor **433** is fed to one of the input terminals of the comparator **434**. In the comparator **434**, the output signal of the low-pass filter is compared with a reference voltage Vref2 (+1.4 V) fed to the other input terminal. An output signal SG**415** of the comparator **434** is fed to the CPU **213**.

The television receiver **100** includes a LAN signal transmission circuit **441**, a terminating resistor **442**, ac-coupling capacitors **443** and **444**, a LAN signal reception circuit **445**, a subtraction circuit **446**, a pull-down resistor **451**, a resistor **452** and a capacitor **453** constituting a low-pass filter, a comparator **454**, a choke coil **461**, a resistor **462**, and a resistor **463**. Herein, the high-speed data line interface **103** is composed of the LAN signal transmission circuit **441**, terminating resistor **442**, ac-coupling capacitors **443** and **444**, LAN signal reception circuit **445**, and subtraction circuit **446**.

Between a power line (+5.0 V) and a ground line, a series circuit of the resistor **462** and resistor **463** is connected. Between a junction point between the resistor **462** and resistor **463** and the ground line, a series circuit composed of the choke coil **461**, ac-coupling capacitor **444**, terminating resistor **442**, ac-coupling capacitor **443**, and pull-down resistor **451** is connected.

A junction point P3 between the ac-coupling capacitor **443** and terminating resistor **442** is connected to the positive output side of the LAN signal transmission circuit **441**, and also connected to the positive input side of the LAN signal reception circuit **445**. A junction point P4 between the ac-coupling capacitor **444** and terminating resistor **442** is connected to the negative output side of the LAN signal transmission circuit **441**, and also connected to the negative input side of the LAN signal reception circuit **445**. To the input side of the LAN signal transmission circuit **441**, a transmitted signal SG **417** is fed from the Ethernet interface **124**.

To the positive terminal of the subtraction circuit **446**, an output signal SG**418** of the LAN signal reception circuit **445** is fed. To the negative terminal of the subtraction circuit **446**, the transmitted signal SG**417** is fed from the Ethernet interface **124**. In the subtraction circuit **446**, the transmitted signal SG**417** is subtracted from the output signal SG**418** of the LAN signal reception circuit **445**. The output signal SG**419** of the subtraction circuit **446** is fed to the Ethernet interface **124**.

A junction point Q3 between the pull-down resistor **451** and ac-coupling capacitor **443** is connected to the ground line via a series circuit of the resistor **452** and capacitor **453**. An output signal of the low-pass filter developed at the junction point between the resistor **452** and capacitor **453** is fed to one of the input terminals of the comparator **454**. In the comparator **454**, the output signal of the low-pass filter is compared

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with a reference voltage V_{ref3} (+1.25 V) fed to the other input terminal. An output signal SG416 of the comparator 454 is fed to the CPU 121 (not shown).

The reserved line 501 and HPD line 502 included in the HDMI cable 610 constitute a differential twisted pair. The source-side end 511 of the reserved line 501 is coupled to the 14 pin of the HDMI terminal 201a, and the sink-side end of the reserved line 501 is coupled to the pin 521 (14 pin) of the HDMI terminal 101. The source-side end 512 of the HPD line 502 is coupled to the 19 pin of the HDMI terminal 201a, and the sink-side end 522 of the HPD line 502 is coupled to the 19 pin of the HDMI terminal 101.

In the audio amplifier 200, the junction point Q1 between the pull-up resistor 421 and ac-coupling capacitor 413 is connected to the 14 pin of the HDMI terminal 201a. The junction point Q2 between the pull-down resistor 431 and ac-coupling capacitor 414 is connected to the 19 pin of the HDMI terminal 201a. On the other hand, in the television receiver 100, the junction point Q3 between the pull-down resistor 451 and ac-coupling capacitor 443 is connected to the 14 pin of the HDMI terminal 101. The junction point Q4 between the choke coil 461 and ac-coupling capacitor 444 is connected to the 19 pin of the HDMI terminal 101.

Next, the actions for LAN communication performed by the high-speed data line interfaces 103 and 203a having the foregoing components will be described below.

In the audio amplifier 200, the transmitted signal SG411 outputted from the Ethernet interface 211 is fed to the input side of the LAN signal transmission circuit 411. Differential signals (a positive output signal and a negative output signal) associated with the transmitted signal SG411 are outputted from the LAN signal transmission circuit 411. The differential signals outputted from the LAN signal transmission circuit 411 are fed to the junction points P1 and P2 respectively, and transmitted to the television receiver 100 over a pair of lines (the reserved line 501 and HPD line 502) included in the HDMI cable 610.

In the television receiver 100, the transmitted signal 50417 outputted from the Ethernet interface 124 is fed to the input side of the LAN signal transmission circuit 441, and differential signals (a positive output signal and a negative output signal) associated with the transmitted signal SG417 are outputted from the LAN signal transmission circuit 441. The differential signals outputted from the LAN signal transmission circuit 441 are fed to the junction points P3 and P4 respectively, and transmitted to the audio amplifier 200 over a pair of lines (the reserved line 501 and HPD line 502) of the HDMI cable 610.

In the audio amplifier 200, since the input side of the LAN signal reception circuit 415 is connected to the junction points P1 and P2, an additive signal between the transmitted signal associated with the differential signals (current signals) outputted from the LAN signal transmission circuit 441 and the received signal associated with the differential signals transmitted from the television receiver 100 as mentioned above is obtained as the output signal SG412 of the LAN signal reception circuit 415. In the subtraction circuit 416, the transmitted signal SG411 is subtracted from the output signal SG412 of the LAN signal reception circuit 415. Therefore, the output signal SG413 of the subtraction circuit 416 corresponds to the transmitted signal SG417 of the television receiver 100.

In the television receiver 100, since the input side of the LAN signal reception circuit 445 is connected to the junction points P3 and P4, an additive signal between the transmitted signal associated with the differential signals (current signals) outputted from the LAN signal transmission circuit 441 and the received signal associated with the differential signals

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transmitted from the audio amplifier 200 as mentioned above is obtained as the output signal SG418 of the LAN signal reception circuit 445. In the subtraction circuit 446, the transmitted signal SG417 is subtracted from the output signal SG418 of the LAN signal reception circuit 445. Therefore, the output signal SG419 of the subtraction circuit 446 corresponds to the transmitted signal SG411 of the audio amplifier 200.

Between the high-speed data line interface 103 of the television receiver 100 and the high-speed data line interface 203a of the audio amplifier 200, bidirectional LAN communication can be performed.

In FIG. 9, the HPD line 502 is used for, in addition to the LAN communication, propagation to the audio amplifier 200 of the fact that the HDMI cable 610 has been plugged into the television receiver 100 at a DC bias level. Specifically, when the HDMI cable 610 is plugged into the television receiver 100, the resistors 462 and 463 and the choke coil 461 in the television receiver 100 bias the HPD line 502 to approximately 4 V through the 19 pin of the HDMI terminal 101. The audio amplifier 200 uses the lo-pass filter, which is composed of the resistor 432 and capacitor 433, to sample the dc bias on the HPD line 502, and uses the comparator 434 to compare the dc bias with a reference voltage V_{ref2} (for example, 1.4 V).

When the HDMI cable 610 is not plugged into the television receiver 100, the voltage at the 19 pin of the HDMI terminal 201a is lower than the reference voltage V_{ref2} because of presence of the pull-down resistor 431. In contrast, when the HDMI cable 610 is plugged into the television receiver 100, the voltage at the 19 pin is higher than the reference voltage V_{ref2} . Therefore, when the HDMI cable 610 is plugged into the television receiver 100, the output signal SG415 of the comparator 434 assumes a high level. Otherwise, the output signal SG415 assumes a low level. Therefore, based on the output signal SG415 of the comparator 434, the CPU 213 of the audio amplifier 200 can recognize whether the HDMI cable 610 has been plugged into the television receiver 100.

In FIG. 9, the pieces of equipment interconnected at both the ends of the HDMI cable 610 have the function of recognizing based on the dc bias potential on the reserved line 501 whether the remote equipment is equipment supporting LAN communication (hereinafter, referred to as e-HDMI compatible equipment) or equipment not supporting LAN communication (hereinafter, referred to as e-HDMI incompatible equipment).

As mentioned above, the audio amplifier 200 pulls up (+5 V) the reserved line 501 using the resistor 421, and the television receiver 100 pulls down the reserved line 501 using the resistor 451. The resistors 421 and 451 do not exist in the e-HDMI incompatible equipment.

The audio amplifier 200 uses, as mentioned above, the comparator 424 to compare the dc potential on the reserved line 501, which has passed through the low-pass filter composed of the resistor 422 and capacitor 423, with the reference voltage V_{ref1} . When the television receiver 100 is e-HDMI compatible equipment and includes the pull-down resistor 451, the voltage on the reserved line 501 is 2.5 V. However, when the television receiver 100 is e-HDMI incompatible equipment and does not include the pull-down resistor 451, the voltage on the reserved line 501 is 5 V because of presence of the pull-up resistor 421.

Therefore, when the reference voltage V_{ref1} is set to, for example, 3.75 V, if the television receiver 100 is e-HDMI compatible equipment, the output signal SG414 of the comparator 424 assumes a low level. Otherwise, the output signal

SG414 assumes a high level. The CPU 213 of the audio amplifier 200 can recognize based on the output signal SG414 of the comparator 424 whether the television receiver 100 is e-HDMI compatible equipment.

Likewise, the television receiver 100 uses, as mentioned above, the comparator 454 to compare the dc potential on the reserved line 501, which has passed through the low-pass filter composed of the resistor 452 and capacitor 453, with the reference voltage Vref3. When the audio amplifier 200 is e-HDMI compatible equipment and includes the pull-up resistor 421, the voltage on the reserved line 501 is 2.5 V. However, when the audio amplifier 200 is e-HDMI incompatible equipment and does not include the pull-up resistor 421, the voltage on the reserved line 501 is 0 V because of presence of the pull-down resistor 451.

When the reference voltage Vref3 is set to, for example, 1.25 V, if the source equipment 110 is e-HDMI compatible equipment, the output signal SG416 of the comparator 454 assumes the high level. Otherwise, the output signal SG416 of the comparator 454 assumes the low level. Based on the output signal SG416 of the comparator 454, the CPU 121 of the television receiver 100 can recognize whether the audio amplifier 200 is e-HDMI compatible equipment.

The pull-up resistor 421 shown in FIG. 9 may be included in the HDMI cable 610 other than the audio amplifier 200. In this case, the terminals of the pull-up resistor 421 are connected onto lines (signal lines), which are spliced or coupled to the reserved line 501 or a power supply (supply potential) respectively, out of the lines included in the HDMI cable 610.

The pull-down resistor 451 and resistor 463 shown in FIG. 9 may be included in the HDMI cable 610 other than the television receiver 100. In this case, the terminals of the pull-down resistor 451 are connected onto the reserved line 501 and a line (ground line), which is coupled to the ground (reference potential), out of the lines included in the HDMI cable 610. The terminals of the resistor 463 are connected onto the HPD line 502 and the line (ground line), which is coupled to the ground (reference potential), out of the lines included in the HDMI cable 610.

FIG. 9 shows an example of the arrangement in the communication system 10 shown in FIG. 1 of the high-speed data line interface 103 of the television receiver 100 and the high-speed data line interface 203a of the audio amplifier 200. The high-speed data line interface 203b of the audio amplifier 200 and the high-speed data line interface 303 of the DVD recorder 300 included in the communication system 10 shown in FIG. 1 are arranged in the same manner.

Next, various operating sequences in the communication system 10 shown in FIG. 1 will be described below. To begin with, referring to the sequence diagram of FIG. 10, a “one-touch recording” sequence for recording a picture (image) being seen on the television receiver 100 will be described below.

(a) When a user uses the remote control transmitter 127 to perform a receiving channel changing manipulation (channel change), (b) the CPU 121 of the television receiver 100 controls the digital tuner 106 and demultiplexer 107 so as to attain a receiving state for the channel selected by the user.

(c) When a receiving channel is changed to another as mentioned above, the television receiver 100 uses the DTCP circuit 116 to encrypt a partial TS extracted by the demultiplexer 107, and then transmits the resultant TS to the DVD recorder 300 via the Ethernet interface 124 and high-speed data line interface 103.

(d) The DVD recorder 300 uses the high-speed data line interface 303 to receive the partial TS sent from the television receiver 100, and uses the DTCP circuit 306 to decrypt the

partial TS. The CPU 311 of the DVD recorder 300 controls the digital tuner 305 and demultiplexer 306 on the basis of channel selection information (packet ID) contained in the partial TS so as to attain a receiving state for the same channel as the channel received by the television receiver 100.

(e) Thereafter, when the user uses the remote control transmitter 127 to instruct recording (one-touch record), the CPU 121 of the television receiver 100 (f) produces an IP packet which contains a remote control code (remote control signal) instructing recording and being received by the remote control receiving unit 126, and (g) transmits the IP packet to the DVD recorder 300 via the Ethernet interface 124 and high-speed data line interface 103.

(h) The DVD recorder 300 receives the IP packet sent from the television receiver 100 using the high-speed data line interface 303. The CPU 311 of the DVD recorder 300 allows the DVD/BD drive 309 or HDD 310 to initiate recording of the partial TS, which is extracted by the demultiplexer 306, on the basis of the remote control code instructing recording and being contained in the IP packet.

(i) The CPU 311 of the DVD recorder 300 produces an IP packet that has recording status information concerning the DVD/BD drive 309 or HDD 310 contained in a payload thereof, and transmits the IP packet to the television receiver 100 via the Ethernet interface 314 and high-speed data line interface 303.

(j) The television receiver 100 receives the IP packet sent from the DVD recorder 300 using the high-speed data line interface 103. The CPU 121 controls, if necessary, the graphic production circuit 110 on the basis of the recording status information contained in the IP packet, and displays the recording status on the display panel 112 while superposing the recording status on an image.

According to the “one-touch recording” sequence mentioned in FIG. 10, when the receiving channel of the television receiver 100 is changed to another, a partial TS containing channel selection information is immediately transmitted to the DVD recorder 300 side via the high-speed data line interface 103. The receiving channel of the DVD recorder 300 is then changed to another. When a user instructs recording, an IP packet containing a remote control command that instructs recording is immediately transmitted to the DVD recorder 300 via the high-speed data line interface 103. Therefore, recording of the partial TS on the receiving channel on which the television receiver 100 is viewed can be immediately initiated in the DVD recorder 300.

Incidentally, FIG. 11 shows as a comparative example the “one-touch recording” sequence to be followed in a case where the pieces of equipment of the communication system 10 shown in FIG. 1 do not include the high-speed data line interface.

(a) When a user uses the remote control transmitter 127 to perform a receiving channel changing manipulation (channel change), (b) the CPU 121 of the television receiver 100 controls the digital tuner 106 and demultiplexer 107 so as to attain a receiving state for a channel selected by the user.

(c) Thereafter, when the user uses the remote control transmitter 127 to instruct recording (one touch record), the CPU 121 of the television receiver 100 (d) converts a remote control code, which instructs recording and is received by the remote control receiving unit 126, into a command employed in HDMI CEC control, and (e) transmits the command to the DVD recorder 300 using the CEC line.

(f) After receiving the recording instructing command, the DVD recorder 300 inquires the television receiver 100 for receiving channel information using the CEC line. (g) In

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response to the inquiry, the television receiver 100 transmits the receiving channel information to the DVD recorder 300 using the CEC line.

(h) Based on the receiving channel information sent from the television receiver 100, the CPU 311 of the DVD recorder 300 controls the digital tuner 305 and demultiplexer 306 so as to square the receiving channel thereof with the receiving channel of the television receiver 100, and (i) allows the DVD/BD drive 309 or HDD 310 to initiate recording of the partial TS extracted by the demultiplexer 306.

(j) The CPU 311 of the DVD recorder 300 transmits the recording status information on the DVD/BD drive 309 or HDD 310 to the television receiver 100 using the CEC line.

(k) Based on the recording status information sent from the DVD recorder 300, the television receiver 100 controls, if necessary, the graphic production circuit 110, and displays the recording status on the display panel 112 while superposing the recording status on an image.

According to the “one-touch recording” sequence mentioned in FIG. 11, after a user instructs recording, the receiving channel of the DVD recorder 300 is squared with the receiving channel of the television receiver 100 in order to initiate recording. Transmission of a recording instructing command from the television receiver 100 to the DVD recorder 300, inquiry for receiving channel information from the DVD recorder 300 to the television receiver 100, and transmission of the receiving channel information from the television receiver 100 to the DVD recorder 300 are performed using the CEC line characteristic of a low transmission speed. Therefore, a very long time is required until recording is initiated after a user instructs recording.

Next, referring to the sequence diagram of FIG. 12, a “theater mode” sequence for changing audio outputs between the television receiver 100 and audio amplifier 200 will be described below.

(a) When a user uses the remote control transmitter 127 to designate a “theater mode,” (b) the CPU 121 of the television receiver 100 controls the audio amplification circuit 114 so as to mute the audio output of the loudspeaker 115. (c) The CPU 121 of the television receiver 100 then produces an IP packet containing a muting canceling command for the audio amplifier 200, and transmits the IP packet to the audio amplifier 200 via the Ethernet interface 124 and high-speed data line interface 103.

(d) The audio amplifier 200 receives the IP packet sent from the television receiver 100 using the high-speed data line interface 203a. Based on the muting canceling command contained in the IP packet, the CPU 213 controls the audio amplification circuit 208 so as to cancel muting of the audio output of the 5.1-channel loudspeaker group 500. Accordingly, a state in which sounds are outputted through the loudspeaker 115 of the television receiver 100 is switched to the “theater mode” in which sounds are outputted through the loudspeaker group 500 connected to the audio amplifier 200.

In this case, the television receiver 100 uses the DTCP circuit 116 to encrypt the partial TS extracted by the demultiplexer 107, and then transmits the resultant partial TS to the audio amplifier 200 via the Ethernet interface 124 and high-speed data line interface 103. The audio amplifier 200 receives the partial TS sent from the television receiver 100 using the high-speed data line interface 203a, and outputs an audio signal, which represents audio data contained in the partial TS, from the audio processing circuit 207. Therefore, when the audio amplification circuit 208 is controlled as mentioned above in order to cancel muting of the audio output of the 5.1-channel loudspeaker group 500, sounds are immediately outputted through the loudspeaker group 500.

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(e) After canceling muting, the CPU 213 of the audio amplifier 200 produces an IP packet having the result contained in a payload thereof, and transmits the IP packet to the television receiver 100 via the Ethernet interface 211 and high-speed data line interface 203a.

According to the “theater mode” sequence mentioned in FIG. 12, when a user designates the “theater mode,” the audio output of the loudspeaker 115 of the television receiver 100 is muted, and an IP packet containing a muting canceling command is immediately transmitted to the audio amplifier 200 via the high-speed data line interface 103. Therefore, the state in which sounds are outputted through the loudspeaker 115 of the television receiver 100 can be immediately switched to the “theater mode” in which sounds are outputted through the loudspeaker group 500 connected to the audio amplifier 200.

FIG. 13 shows as a comparative example the “theater mode” sequence to be employed in a case where the pieces of equipment of the communication system 10 shown in FIG. 1 do not include the high-speed data line interface.

(a) When a user uses the remote control transmitter 127 to designate the “theater mode,” (b) the CPU 121 of the television receiver 100 controls the audio amplification circuit 114 so as to mute the audio output of the loudspeaker 115. (c) The television receiver 100 inquires the audio amplifier 200 for a muting situation using the CEC line. (d) In response to the inquiry for the muting situation, the audio amplifier 200 transmits the muting situation to the television receiver 100 using the CEC line.

(e) When muting is not canceled in the audio amplifier 200, the CPU 121 of the television receiver 100 returns a CEC command, which instructs muting cancelation, to the audio amplifier 200 using the CEC line. (f) Based on the CEC command, the audio amplifier 200 controls the audio amplification circuit 208 so as to cancel muting of the audio output of the 5.1-channel loudspeaker group 500. Accordingly, the state in which sounds are outputted through the loudspeaker 115 of the television receiver 100 is switched to the “theater mode” in which sounds are outputted through the loudspeaker group 500 connected to the audio amplifier 200. If the high-speed data line interface is not included, feeding audio data from the television receiver 100 to the audio amplifier 200 is achieved over, for example, an optical cable.

(g) After canceling muting, the CPU 213 of the audio amplifier 200 transmits the result to the television receiver 100 using the CEC line.

According to the “theater mode” sequence mentioned in FIG. 13, after a user designates the “theater mode,” the television receiver 100 inquires the audio amplifier 200 for a muting situation. If muting is not canceled, the television receiver 100 transmits a CEC command, which instructs muting cancelation, to the audio amplifier 200 so as to switch the state to the “theater mode.” Therefore, the time that elapses until the state is actually switched to the “theater mode” after the user designates the “theater mode” gets longer. According to the “theater mode” control sequence mentioned in FIG. 13, the optical cable over which audio data is transmitted is needed in addition to the HDMI cable 610.

Referring to the sequence diagram of FIG. 14, a “remote control” sequence will be described below. Incidentally, FIG. 14 is concerned with a case where a remote control code is transmitted from the television receiver 100 to the DVD recorder 300.

(a) While a user is depressing a predetermined button (remote control button) of the remote control transmitter 127, the CPU 121 of the television receiver 100 (b) produces an IP packet containing a remote control code received by the remote control receiving unit 126, and (c) transmits the IP

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packet to the DVD recorder **300** via the Ethernet interface **124** and high-speed data line interface **103**.

(d) The DVD recorder **300** receives the IP packet sent from the television receiver **100** using the high-speed data line interface **303**. The CPU **311** of the DVD recorder **300** interprets the remote control code contained in the IP packet and controls the relevant part of the DVD recorder **300**. In this case, the CPU **311** can learn the length of the user's depression of the button from the receiving duration for the IP packet, and can interpret the remote control code in consideration of the length of the depression.

(e) When the user ceases depression of the predetermined button of the remote control transmitter **127**, (f) the CPU **121** of the television receiver **100** terminates production of the IP packet containing the remote control code.

According to the "remote control" sequence mentioned in FIG. **14**, the television receiver **100** produces an IP packet containing a remote control code, transmits the IP packet to the DVD recorder **300** via the high-speed data line interface **103**, and controls the actions in the DVD recorder **300**. Therefore, in the television receiver **100**, the processing of converting the remote control code into, for example, a code defined under the CEC becomes unnecessary. Likewise, in the DVD recorder **300**, the processing of converting the code defined under the CEC into the original remote control code becomes unnecessary. The pieces of processing on the transmitting and receiving sides respectively of the remote control code are simplified. The television receiver **100** transmits an IP packet containing the remote control code to the DVD recorder **300** via the high-speed data line interface **103**. Remote control of the DVD recorder **300** from the television receiver **100** side can be quickly achieved.

FIG. **15** shows as a comparative example a "remote control" sequence to be employed in a case where the pieces of equipment of the communication system **10** shown in FIG. **1** do not include the high-speed data line interface.

(a) When a user depresses a predetermined button of the remote control transmitter **127**, (b) the CPU **121** of the television receiver **100** converts a remote control code received by the remote control receiver **126** into a CEC command according to a code list defined under the CEC. (c) The CPU **121** transmits the CEC command to the DVD recorder **300** using the CEC line. (d) The CPU **311** of the DVD recorder **300** reconverts the CEC command sent from the television receiver **100** into the remote control code, interprets the remote control code, and controls the relevant part of the DVD recorder **300**.

(e) Thereafter, if the user ceases depression of the predetermined button of the remote control transmitter **127**, the CPU **121** of the television receiver **100** (f) produces a command defined under the CEC, and (g) transmits the CEC command to the DVD recorder **300** using the CEC line. (h) The CPU **311** of the DVD recorder **300** terminates interpretation of the remote control code on the basis of a command signifying cease of the depression of the remote control button and being sent from the television receiver **100**.

According to the "remote control" sequence mentioned in FIG. **15**, the television receiver **100** converts a remote control code into a CEC command according to the code list defined under the CEC, and transmits the CEC command to the DVD recorder **300**. The DVD recorder **300** reconverts the sent CEC command into the remote control code and interprets the remote control code. The processing loads incurred by the transmitting and receiving sides of the remote control code are therefore increased. Since the CEC line characteristic of a

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low transmission speed is used to send the remote control code, if the data length of the CEC command is long, a delay may be invited to the remote control of the DVD recorder **300** from the television receiver **100** side.

As described so far, in the communication system **10** shown in FIG. **1**, the bidirectional communication unit using two lines (the reserved line and HPD line) of the HDMI cable **610** or **620** is used to transmit channel selection information, a remote control code instructing recording, "theater mode" designating information, a remote control code, or the like from the television receiver **100** to the audio amplifier **200** or DVD recorder **300**. The operating state of the audio amplifier **200** or DVD recorder **300** can be quickly controlled.

In the foregoing embodiment, the high-speed bidirectional communication unit using the reserved line and HPD line of the HDMI cable has been described. The high-speed bidirectional communication unit may be constructed using the other lines of the HDMI cable.

In the aforesaid embodiment, a description has been made on the assumption that the interface conformable to the HDMI standards is adopted as a transmission line between pieces of equipment. The invention can apply to any other similar transmission standards. In the aforesaid embodiment, the communication system **10** includes the television receiver **100**, audio amplifier **200**, and DVD recorder **300**. The invention can apply to a similar communication system including the other pieces of equipment.

In the aforesaid embodiment, bidirectional IP communication is performed between pieces of equipment. Bidirectional communication can be performed under any protocol other than the IP. In the aforesaid embodiment, the pieces of equipment are interconnected over the HDMI cable. The invention can also apply to a case where the pieces of equipment are interconnected by radio.

INDUSTRIAL APPLICABILITY

The invention permits quick control of the operating state of source equipment side from sink equipment, and can apply to a communication system having multiple pieces of equipment HDMI-interconnected.

What is claimed is:

1. A communication method for performing reception of video data and audio data, communication of device control data, and local area network communication by using a single cable, the method comprising the steps of:

connecting a connectable device to a pair of differential transmission lines;

performing the local area network communication through bidirectional communication via the pair of differential transmission lines;

notifying a connection state of an interface with the connectable device by using a DC bias potential of at least one of the differential transmission lines of the pair, wherein the connection state includes a first notification from a first one of the pair of differential transmission lines whether the connectable device is connected to the single cable;

inquiring the connectable device for a muting situation using consumer electronic control (CEC) line;

receiving the muting situation in response to the inquiry; and

displaying the video data which is received.

* * * * *